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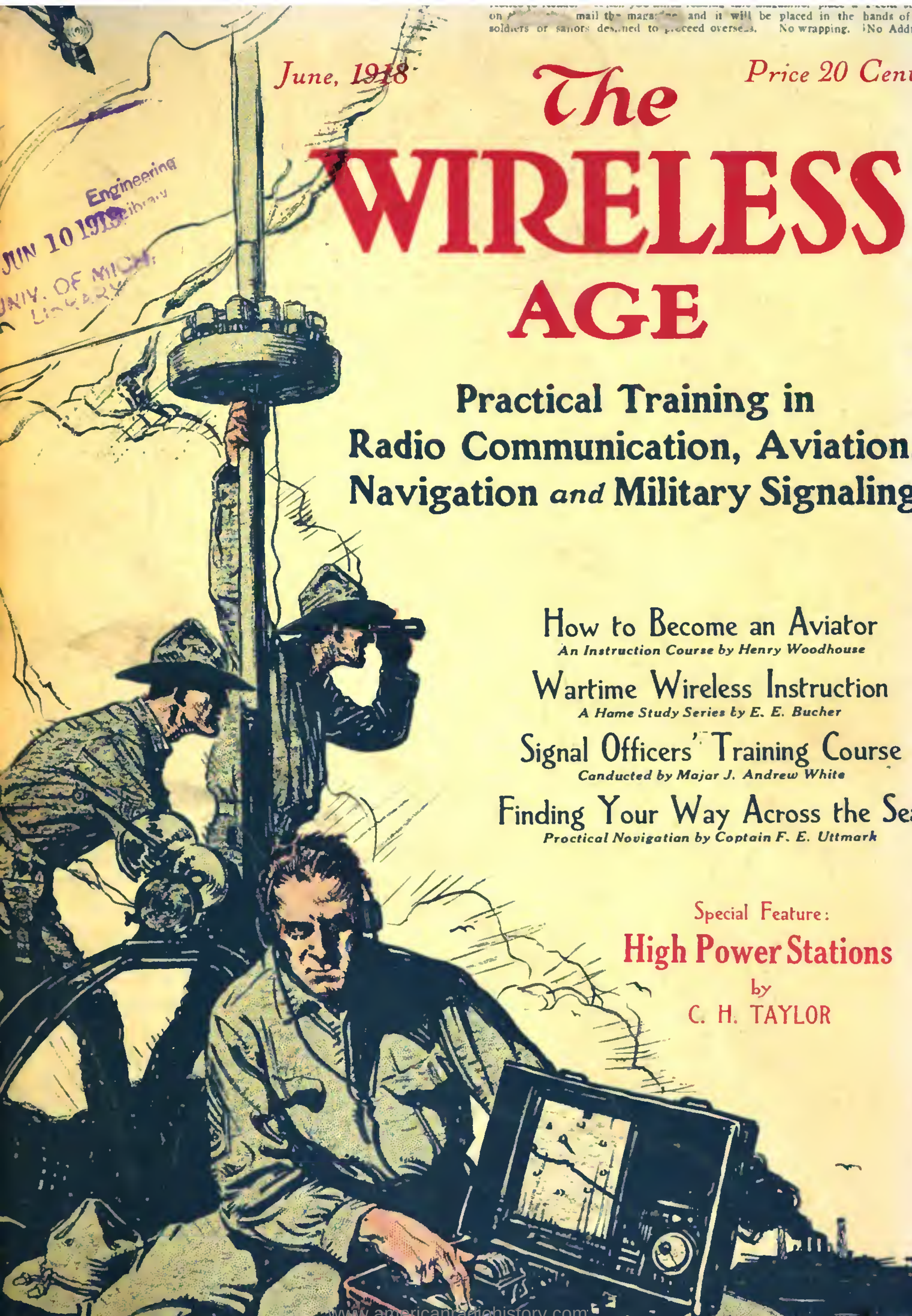

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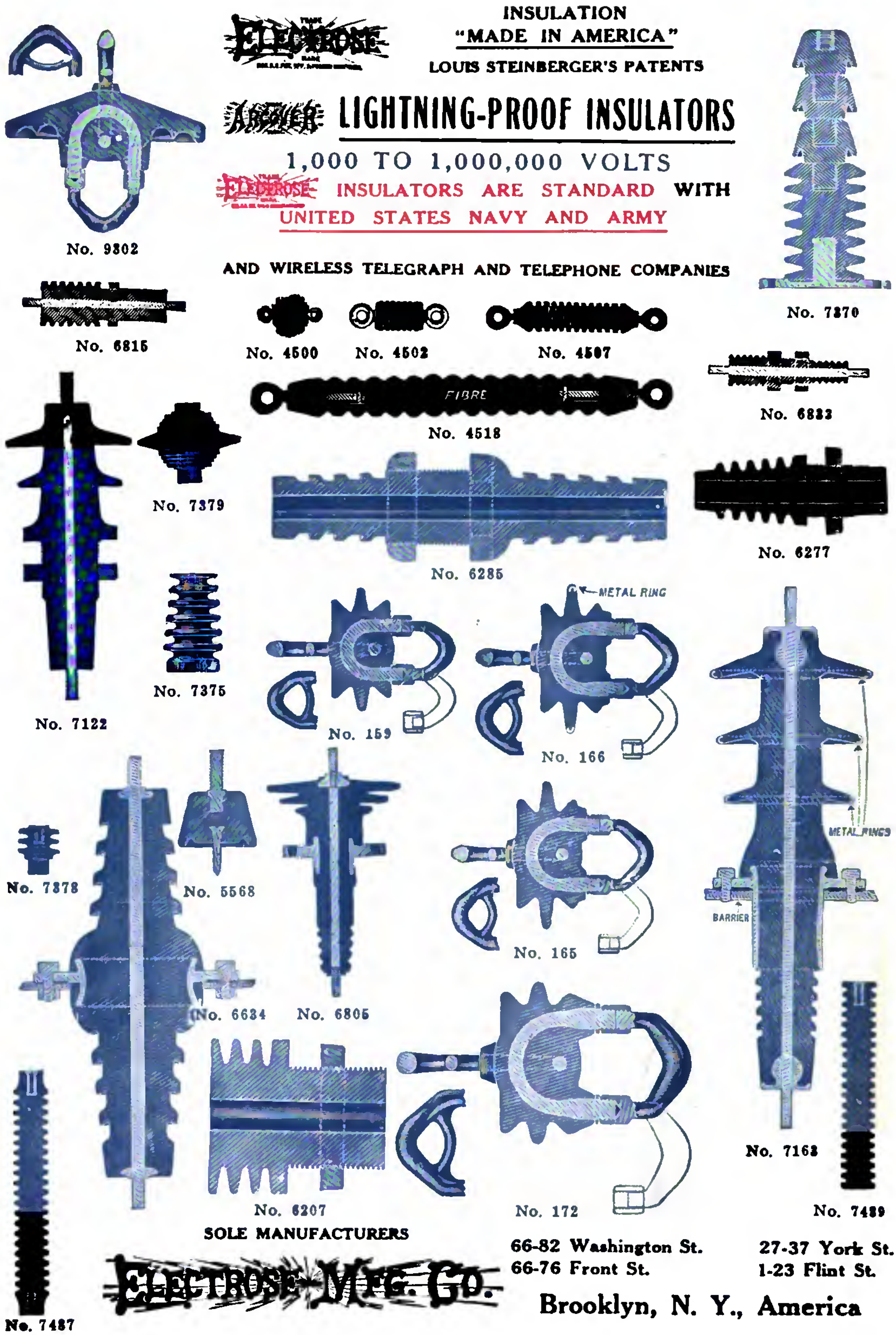
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That remarkable body of men, the British Royal Engineers, are represented here with radio pack set in field operation, receiving reconnaissance reports from an airplane scout

THE WIRELESS AGE

WORLD WIDE WIRELESS

Naval Radio in a Year of War

THROUGH the Committee on Public Information, the Navy Department has issued the following statement of its activities in radio communication in the first year of America's participation in the war:

The President on April 6, 1917, directed the Navy Department to take over such radio stations as might be required for naval communications, all others being closed. The enforcement of this order fell to the Director of Naval Communications, and 53 commercial radio stations were taken into the Naval Communication Service. On account of duplication, 28 commercial radio stations closed. Thousands of small amateur radio stations were closed. At present no radio communication is permitted on United States territory (not including Alaska) except through stations operated by this department or by the War Department.

Soon after the war opened the demand for radio operators increased and the representative of the Naval Communication Service in each district began conduct of a radio school for preliminary training in radiotelegraphy. To coordinate training, a central final training school was demanded. Harvard University early last summer offered the use of buildings, dormitories, and laboratories for this purpose, and the offer was accepted. From a small beginning; the naval radio school at Harvard has now developed into one of the largest educational institutions in the country.

At Mare Island, Cal., is located another final training school. At these two schools men are put through a four months' course, which embraces not only radiotelegraphy and allied subjects, but the military training necessary for all enlisted men. At present nearly 5,000 men are under instruction in these two schools alone. Classes are graduated each week and operators are assigned to service. Applicants for this service are accepted at any Navy recruiting office.

The Navy is providing the required operators for the rapidly increasing list of naval ships. It has also undertaken to supply radio operators for all merchant vessels in trans-Atlantic service, and is, to this extent, assisting the Shipping Board in manning such vessels.

The Naval Communication Service provides for communication by radio between the United States and its Asiatic possessions and territories. During the past year the high-powered stations at San Diego, Cal., Pearl Harbor, Hawaii, and Cavite, P. I., have been completed and put into commission. The Naval Communication Service also provides direct radiotelegraphic communication between America and Europe, and as part of this service it recently announced the accomplishment of the first radiotelegraphic communication between Italy and America.

Marconi Damage Claim for British Imperial Chain Admitted

THE stir-up in the British Parliament several years ago which acquired the misnomer "Marconi Scandal" held the limelight once again in London, in the middle of March. The suit of Marconi's Wireless Telegraph Co., Ltd., for damages growing out of the repudiation of the contract awarded it to build an Imperial Wireless Chain of stations for the British Government, reopened the controversy, which is expected to disclose some hitherto unknown facts governing pre-war ministerial actions, although the Attorney General has already admitted the Marconi Company's claim for damages.

It has come about in this way: In 1913 a Select Committee was appointed by the House of Commons to investigate and report upon the development of wireless telegraphy, with Sir Charles Hobhouse, a sometime Liberal office-holder, as chairman. Among the members of the committee was Henry Norman, M. P., since created a Baronet and a member of the Privy Council.

In July of 1913 the then Postmaster General, Herbert Samuel, entered into a contract with the Marconi Company for the construction and installation of an "Imperial Wireless Chain" at specified points throughout the British Empire. In December of 1914 the new Postmaster General, Sir Charles Hobhouse, repudiated the contract with the Marconi Company, and the company brought suit against the Government for a declaration that this repudiation was wrongful, claiming damages.

This suit was brought to trial a month ago and terminated somewhat strangely by the Attorney General suddenly abandoning the defense on behalf of the Government, agreeing to the declaration which the Marconi Company sought and admitting its claim for damages.

Godfrey Isaacs, Earl Reading's brother, as managing director of the English Marconi Company, produced a letter at the trial which forms the basis of the present promising affair. When Sir Charles Hobhouse became Postmaster General, in 1914, he went to Berlin to see for himself what the Germans, especially the Telefunken Company, were doing in perfecting long-distance wireless, and took Sir Henry Norman with him as interpreter, the latter speaking German and being well acquainted with the technology of wireless. After their return from Berlin, Godfrey Isaacs received a letter from two friendly directors of the Telefunken, saying that Hobhouse and Norman had suggested that the Telefunken should tender for the second trio of British imperial wireless stations for which the Marconi had already a provisional contract. The Telefunken reply was that they could not hope to undercut the Marconi in England, as the expenses of the Telefunken, owing to the cost of licenses, etc., would be higher than those of the Marconi, besides which their patent position in England was uncertain. The Telefunken directors' letter went on: "From this Norman formed the opinion that there would be little question of relying upon the Telefunken Company as a competitor of the Marconi in England, and he therefore approached Herr von Lepel with the object of encouraging him to form an English company and to obtain for him financial assistance. With this object, among others, we understand, these gentlemen are endeavoring to obtain financial assistance from Mr. Beit" (presumably the South African millionaire).

That the British Postmaster General and a member of Parliament (Norman held no official position at this time), should offer inducements to a German undertaking to come and cut the ground from under a British one would not have been popular even when it was alleged to have been done, while in the present state of feeling, it is a very ugly business indeed, and is so accepted by these two gentlemen, who both indignantly denied in the House of Commons that they had ever made such a suggestion to the Telefunken Company.

When the suit came on Hobhouse was subpoenaed by the Marconi Company, but, as already stated, the Attorney General for the Government suddenly surrendered before either Hobhouse or Norman gave evidence. They both made statements in the House of Commons absolutely denying the allegation of the Telefunken directors, but some members wanted to know why they had not done so in the witness box, where they could have been cross examined, instead of the House, where Isaacs was not in a position to challenge them. He wrote to the press the next day reaffirming everything he had said in his letter to Postmaster General Pease, and inviting Hobhouse and Norman to repeat their statements outside the House so that he could take legal proceedings to substantiate them.

Sir Charles Hobhouse has replied declining to do this, and Godfrey Isaacs has rejoined that he is not going to let the matter rest.

Dr. Braun, Famous German Scientist, Dead

DR. FERDINAND BRAUN, eminent German scientist, who shared the Nobel prize with Guglielmo Marconi in 1905 for distinguished achievements in the invention of improved methods for wireless telegraphy, died a prisoner in the Kings County Hospital, New York, April 19th, from heart disease, which was superinduced by an overdose of morphine.

Dr. Braun was found unconscious in his room in the home of his son, Conrad Braun. On a table beside him were two empty bottles, which the police charged had contained morphine, and another bottle partly filled with the same drug. Relatives of the scientist summoned a policeman, and he sent in a call for an ambulance.

Dr. Blauvelt hurried the unconscious man to the hospital, where ineffectual efforts were made to restore him to consciousness. Pending Dr. Braun's expected recovery, a charge of having narcotics in his possession was made against him, but he died without being able to make any explanation of how the drug came into his possession.

His son told the police he knew of no reason why his father should have attempted to take his own life, and that the overdose of the drug must have been taken by accident. In the police records Dr. Braun is listed as a music teacher.

Dr. Braun came to this country from Germany early in 1914 as a witness in litigation between the Marconi Wireless Telegraph Company and the Atlantic Communication Company which built and operated the wireless station at Sayville, L. I.

In Germany he was called the "wireless wizard" and was credited there with having done more than any one else to perfect control of the new system of communication.

Marconi, upon the outbreak of the European war, was summoned hurriedly back to Italy to take his place as an officer in that country's army. As a result, the litigation which had brought Dr. Braun to this country was indefinitely postponed. He was taken ill and was reported to be dying immediately afterward. Dr. Braun was born in Fulda, Germany, in 1850, and early became interested in scientific research work.

He studied at several universities in Germany and then went to Scotland to complete his education. Returning to Germany he taught for several years at Karlsruhe, but in recent years he was professor of physics at the University of Strassburg. At various times he also held important posts in the schools of physics at Wurtemburg, Leipsic and Tubingen.

Wireless telegraphy claimed Dr. Braun's attention in 1898, and for many years after that he applied himself almost exclusively to the task of solving its problems.

Dr. Braun had written extensively on wireless subjects and was well known in this country through his many contributions to the Electrician and other scientific journals.

Funeral services were held April 23rd. The Rev. Dr. William Jung, of the German Lutheran Church, conducted the services in German. He made a plea for a spirit of fairness on the part of German aliens toward the United States, and said that if all Germans in this country had judged the nation as fairly as the dead man had done, there would not be such a strong feeling against German aliens.

Great Britain's Use of Women Telegraphists

ENGLISH GIRLS are qualifying fast for positions as wireless telegraphists, says the Pall Mall Gazette. They have not yet been placed on ships, the objections being that they cannot shin up the masts and make repairs.

They are, however, being used extensively in some high power land stations. Some time ago England started a special training school for women in North Wales, only accepting applicants who are already experienced post office telegraphists. The Government gives them additional training in wireless work, and when they become expert in slip reading, punching, record reading, sending on long lines and the general duties of a commercial wireless station, they are drafted out as required. They go on night duty in rotation.

New High Power Station for Japan

THE Japanese Budget for the next fiscal year contains an item of $350,000 for the creation of a new wireless station at Taira in Fukushima. This site is on the Pacific coast and is thought to be an excellent one for direct communication with America. The volume of communication has increased of late over 50 per cent. The present wireless station at Choshi will be used entirely for communicating with ships on the Pacific.

Chinese Naval Radio Station Proposed

NEGOTIATIONS for construction of wireless stations at Chefoo, Shanghai and other points in China have been in progress between representatives of a Japanese company and the Minister of the Navy, Admiral Liu Kuanhsiung, since last March, according to seemingly reliable information, says the Chinese National News Agency. A loan agreement with a Danish company has been canceled by the Chinese Government on payment of monetary compensation to the Danish firm.

The Japanese demand for the privilege of building wireless stations in China is said to be based on a claim that wireless is closely connected with the national defense of Japan. It is stated the Japanese proposed to lend more money to China for that purpose under conditions similar to those proposed by the Danish firm. The wireless stations are required primarily by the Chinese navy and not at present for commercial purposes, it is announced.

Count Szechenyi's Submarine Wireless Company Seized

SEIZURE of the Submarine Wireless Company of New York, incorporated at Albany in August, 1912, on the strength of a wireless invention by Count Laszio Szechenyi, who married Gladys Vanderbilt, was announced on May 3rd at the office of the Alien Property Custodian in Washington, D. C. The steps leading up to the seizure were conducted with the greatest secrecy.

About two-thirds of the stock is held by enemy aliens, principally titled Austrians and Germans. It was on the strength of this showing that the seizure was ordered, it is believed, and not because the company was suspected of hostile action or intent.

The capital stock originally was $100,000. This was later increased to $500,000, the amount now outstanding.

Among the titled persons listed as holding stock in the concern are Count Julius Andrassy, Prince Johann Lichtenstein, Count Stefan Szechenyi, Prince Louis Windischgraetz, Count Alex Andrassy and Count Paul Esterhazy.

High Power Stations

Some Features of the Long Distance Stations of the American Marconi Company

By C. H. Taylor

Engineer, Transoceanic Division, Marconi Wireless Telegraph Co.

WHILST the progress of wireless in the territories, colonies and dominions of the Entente Allies, though wonderful to a degree, cannot be discussed in print, that of America stands out for all the world to see. Especially is this the case with the erection and opening of long distance stations. The high power installations erected in New Jersey and Massachusetts by the Marconi Wireless Telegraph Company of America, for the purpose of long distance communication with the United Kingdom and Norway respectively, afford excellent examples of this activity. There are other important items in the Marconi programme into which it is not necessary for our present purpose to enter; but in view of the recent opening of the extension of the Marconi Pacific Service to Japan, it may be of interest to those who devote some attention to radio-telegraphic matters to have, as here set forth, an account of these important and up-to-date installations.

The general design of these stations was decided upon in the spring of 1912, and there was—so far as the radio equipment is concerned—no important modification made subsequently when the material was fabricated. Broadly speaking these stations, from a radio point, are members of an organized system designed for long distance communication throughout the world.

It can be readily seen that a group of powerful long distance stations can be operated most effectively if all members of the group are designed not as isolated units but as component parts of one large group. This is the procedure that has been adopted, and the wave-lengths and spark-frequencies assigned to

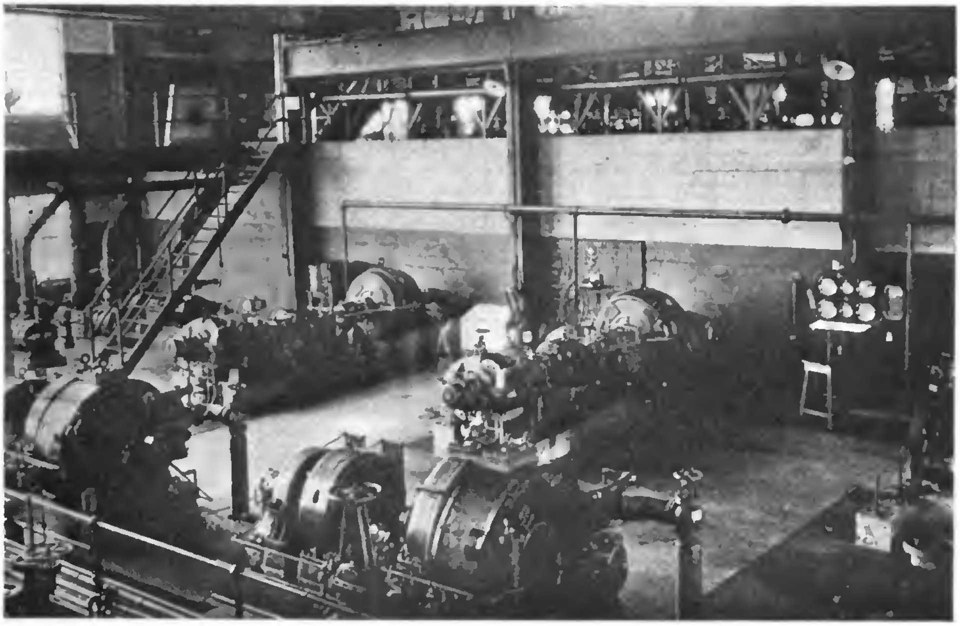

Figure 1a—Machinery floor of power house showing turbo-alternators, Kahuku, Hawaii

each of the various units were considered with greater reference to the complete group than to the individual circuit.

It is not our present intention to describe the power-supply equipment of these stations, as the points of greatest interest will be (*a*) those relating to the methods adopted to utilise effectively for radio work the primary power with which these stations are equipped, and (*b*) those relating to the success of these methods.

In the primary-power circuit the equipment at all these stations is similar. The unit for the supply of power to the radio circuits has a full load rating of 300 kw. An illustration showing a typical instance will be seen in figure 1a. It is in every case directly connected to the prime mover—either a steam turbine taking steam from their own steam mains; or a motor, taking power from public

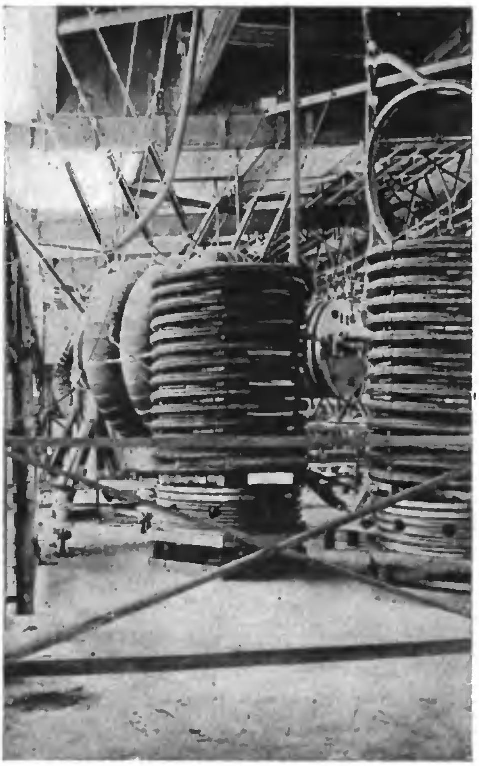

Figure 1b—High frequency inductance at Kahuku, Hawaii

service mains. The various accessory machines are driven from the same source of power, and are standard machines that call for no comment here.

These 300 kw. alternators possess special features of their own. The frequency is, from a power-station point of view, high; and varies for each station. This was deliberately arranged for, in order to assist in the selectivity at the receiving station. It was considered that it might not be possible to operate all the many proposed long-distance stations without some interference with each other, so the radio and audio frequencies are both varied with each station. The point of most interest about these alternators is that the stators of these machines are not fixed rigidly to the frames. The stator unit sits on a bearing inside the frame and is capable of being rotated thereon. The arc through which it turns is large enough to allow its position relative to that of the rotor to be changed through an amount at least equal to the pole arc. These adjustments are made by means of a small hand wheel fastened rigidly to a threaded spindle. This spindle engages with a lug on the stator unit, and as the hand wheel is rotated, the stator is turned in relation to the rotor. A split collar and pinching screw are sufficient to hold this spindle in any desired position.

This type of construction was adopted because it was decided to drive the discharger through an extension of the rotor shaft and it was necessary to provide means for the control of the sparking instant. By the construction outlined above it is possible to make the alternator potential maximum occur at any desired position of the rotor shaft. The adjustment provided on the stator of the alternator is sufficient to allow the potential of the machine to be varied from O to its

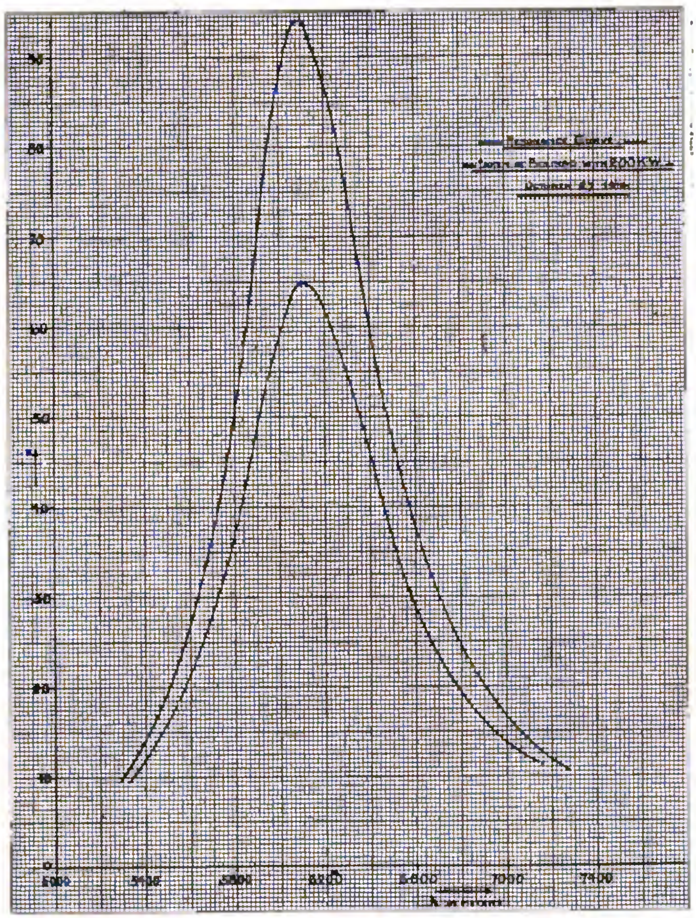

Figure 2—Resonance curve

positive or its negative maximum for the instant when the rotating studs on the discharger successively enter the spark zone. The correct position for the stator with relation to the beginning of each condenser discharge must be ascertained for each wave change as this position appears to vary with the make up of the primary radio circuit.

In practice these adjustments are not difficult. The circuit is loaded, and the power input held constant while the stator is turned until the reading on the wattless component meter is a minimum and that on the thermoammeter in the antenna circuit is a maximum. It has been found that the setting done at the power house can be very accurate. Tests have been carried out over the long distance circuit to ascertain what error was liable to creep in by leaving this adjustment entirely in the hands of the transmitting station with the result that the receiving station audibility curve confirmed the transmitting station's adjustment.

Four resonance transformers each of 75 kva. rating raise the voltage at which the power is received from the alternator from 2,000 to a higher voltage at which it is more conveniently used in the primary radio circuit.

An interesting paper on the circuit has already been presented to the Institute of Radio Engineers by Mr. Hallborg, and for this section of the work readers are referred to his paper, which figures in the printed proceedings of the Institute. An example of a resonance curve will be found in figure 2.

The other feature of interest in this low frequency circuit is the operating control switch.

The control of the radio circuits for operating purposes has been placed in the condenser feeding circuit. This position has stood the test of exhaustive trials and is in common use at all Marconi power stations.

These switches make and break the circuit through which the charging current flows into the condenser bank. One of these switches is inserted in each line so that there is a complete break between the condenser and the feeding circuit. Each switch puts two breaks into the line that it controls. These switch keys are of the moving coil type operated by means of a change in the direction of the current flowing through one of the two sets of windings. Normally, the direction of the currents in the two groups of windings is such as to hold the switch arm in that position which makes a break in the high tension feeding line. When the direction of the current in one of these two groups of coils is changed, the switch arm moves over until it makes contact with a stationary contact holder; the high tension line is thus closed, and the current can then flow into the condenser bank and charge it. The distance through which these moving arms swing depends upon the rate at which operation is to be carried out.

Since the gap opened in this circuit is small and the voltage of the interrupted circuit is high, an arc will follow the break here every time the high tension circuit is interrupted. If this were allowed to persist, the signals would be distorted and rendered unintelligible. Consequently an air blast is played upon these contacts and the arc that follows each interruption is blown out.

In order that high speeds may be possible with these keys, the moving parts are made very light, yet sufficiently strong to withstand the tremendous hammering that they must endure when being operated at a good telegraph speed. The present type of key is the result of several successive eliminations of varieties that have been shown to have some defect, after being put through the severe test of commercial operation over an extended period.

With this key it is possible to operate cleanly at speeds of 75 words per minute, and the key has been tested up to a speed of 100 words per minute, without distortion of the signals.

The primary oscillation circuit naturally divides itself into three groups—the condenser bank and its connections, the coupling coil, and the discharger.

The units of this condenser are made up of thin sheets of zinc suspended in stoneware containers filled with insulating oil. Between each pair of zinc sheets is stood a glass plate approximately 1/8-inch thick. This type of condenser has proved in practice to have losses that are less than those developed in that type which has the conducting sheet pasted on to the glass plate.

The oil used in these tanks was carefully chosen and was forced through a filter press before being passed into the containers. An interesting fact has recently developed in connection with the oils used in condensers of this type. It has been found that condensers built in this fashion have, at certain stations, modified the characteristics of the oil during service. Units taken out of service after about a year's work have shown a fairly hard deposit on the surface of the glass. This deposit, which is yellow in color, does not come away from the surface at all easily; in fact, it seems to get pressed tightly into it. In some instances when this has been removed from the glass the surface shows a clearly defined outline where the edges of the zinc sheet rested. Other instances have been reported in which this change in the oil is only one of thickening, in which the oil becomes changed to the consistency of vaseline. The oil has not been purchased from the same firm in all such cases, but has been bought in widely separated localities, so that it cannot be attributed to any one particular grade of oil. At present this oil change has not been noticed in the tanks that are known to have been supplied with oil forced through the filter press, so it is very probably due to traces of water in the oil.

As the spark frequency adopted at these stations is low, the energy per spark is correspondingly high. In order to avoid excessive potentials in the primary circuit, the value of the capacity has been kept large. In consequence, the condenser bank covers a rather large area, which has necessitated the careful design of the condenser buses and the arrangement of the tanks.

It is found absolutely necessary to have the buses and the tanks arranged so that they form an electrically symmetrical circuit. For convenience in operating, we have divided up the bank into a number of small groups, each of which is fed and discharged by a separate bus. Each of these group buses is of the same length, shape and relative space location, and these sets are joined to the main bus in as symmetrical a manner as possible, so that this bus will have a minimum disturbing effect on these units.

Moreover, practical experience shows it to be of the utmost inportance that the value of the capacity connected to each of these group buses should be identical. If this be not the case, any out-of-balance effect is at once made noticeable by surges which break down the air insulation between the buses, or which may break down the air-gap between the two halves of the condenser group bus. Instances of this splashing have occurred at points where, so far as can be seen, good balance is maintained, and investigation has disclosed the fact that there may exist along the tank bus potential differences at points that were to all appearances identical with respect to the electrical circuit.

In order to carry without much loss the heavy maxima currents, which occur on the discharge through the spark gap of this condenser, the main buses are each made of copper strip 24 inches wide and ⅛-inch thick. These two halves of the bus are set up close together, parallel to one another, and separated by an air-space which can be varied between limits. In this manner the inductance of these buses is reduced as much as possible.

In these stations the coupling coil is quite a massive affair. The primary coil, which has the larger diameter, is held stationary, and the secondary is mounted on a frame that allows it to be moved relatively to the primary, in order that the coupling between these two circuits may be varied. Our illustration in figure 1b will give a very fair idea of the arrangement. Each primary turn has a mean diameter of 5 feet, the external diameter over the winding being slightly more than 6 feet. Each of these turns comprises a number of cables laid around a non-conducting core—in this case of wood—which has a circular cross-section 12 inches in diameter. Each cable comprises 7 copper wires each separately insulated by a double cotton covering. The winding is laid around the core in a spiral fashion so that each cable makes at least one turn across the core while it is laid around the ring. In this manner all these wires are kept the same length between the ends of each turn; and each wire is electrically identical, ensuring, as far as possible, an equal current distribution throughout these cables.

The number of the above-mentioned primary turns varies at these stations from two to four.

The condenser is discharged by the well-known Marconi rotary disc type of discharger, built on a large scale, so as to enable it to handle the very large currents employed at these stations. The disc of this machine, figure 3, is 50 inches in diameter. It is made of high tensile steel, and must undergo a test run for one hour at 3,000 RPM before being accepted. In station practice it is seldom run over 2,500 RPM. The electrodes fitted to this disc are copper studs having a cross section of 3 by 1 inches, the latter being the section in the direction of motion. The width of the side electrodes can be varied between the limits ¾ and 1½ inches.

With this type of machine, the discharge of the large condenser may be controlled so that at a reasonably loose coupling the energy may be efficiently transferred to the secondary circuit, and the radiation from that secondary circuit may be confined practically to a single wave length. In order to attain this end, it is necessary to proportion the sparking zone so that the duration of the spark and the time required to transfer the energy at the coupling used are in agreement. With these machines it is not very easy to gauge with absolute accuracy the length

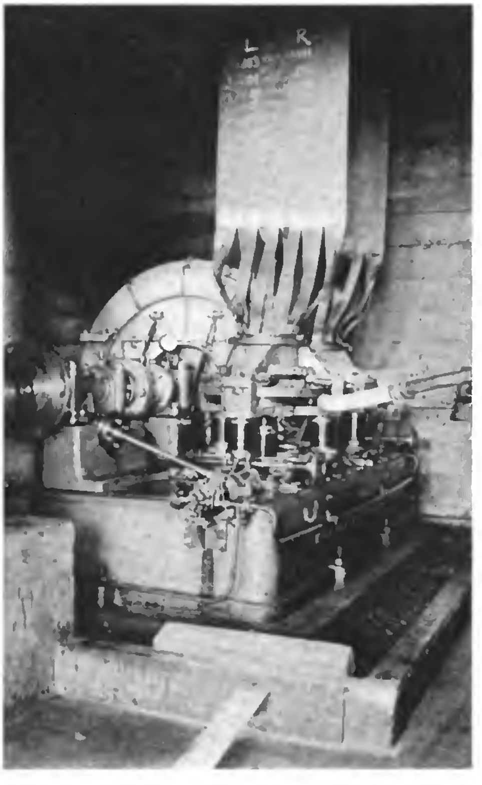

Figure 3—Synchronous Spark Discharger for high power station, 100 *to* 300 *kw.*

of the spark zone. The position of the stud at the beginning of the discharge can be ascertained from the known potential maximum, the dimension of the electrodes and the size of the gaps between the stationary and rotating members. This is held to the minimum needed to give mechanical clearance when all the parts have reached their steady working temperature. In general it will be of the order of 4/1000 inch in each gap. The position of the stud at the end of the discharge is not so definitely located. Since the speed of the machine is fixed, being determined by the alternator speed, any change in the duration of the discharge must be effected by alterations to the studs, or to the electrodes, or to both. Small variations can best be carried out by changes to the width of the electrodes.

(To be continued)

Progress in Radio Science

THE DYNATRON

A Vacuum Tube Possessing Negative Electric Resistance*

By Albert W. Hull, Ph.D.

Research Laboratory, General Electric Company, Schenectady, New York

(*Continued from May* WIRELESS AGE)

4. Dynatron in Circuit Containing Positive Resistance A. Series Connection. Circuit with Zero Resistance

If the dynatron is connected in series with a circuit containing positive resistance, the total resistance of the circuit is the algebraic sum of the positive and negative resistances, and may be made as small as desired by making the positive and negative resistances nearly equal. Such a circuit has very interesting properties. For, while the total resistance of the circuit is very small, that of its parts, individually, is not. Hence a small change in the e.m.f. applied to the whole circuit will cause a comparatively large change in current, and therefore in the iR drop across each part separately; i. e., the circuit acts as a voltage amplifier.

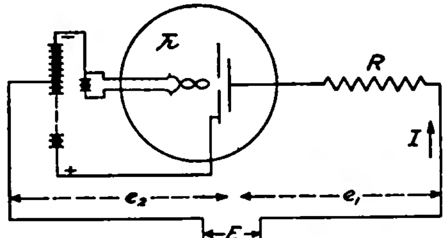

Figure 7

The connections are shown in figure 7. An ohmic resistance R is connected in series with a dynatron of negative resistance $\bar{r}$, the battery terminal of the dynatron being connected at the point V_0 corresponding to the voltage at which the dynatron current is zero.[2] (B, figure 3.) If an e.m.f. E be impressed across the combination, causing a current I to flow and a voltage drop e_1 in the ohmic resistance and e_2 in the dynatron, then

[2]The amplification of *voltage changes* remains the same if the battery terminal of the dynatron is at some other point than that corresponding to the point B in Figure 3, provided it be in the range A—C (Figure 3) over which the dynatron curve is straight. In that case the equations are

$$e_1 = I\,R$$

$$e_2 = I\,\bar{r} - I_0\bar{r}, \text{ where } I_0 \text{ is a constant}$$

hence $$E = I\,(\bar{r}+R) - I_0\bar{r}$$

$$\frac{de_1}{dE} = \frac{R}{R+\bar{r}}, \text{ that is}$$

voltage changes are amplified in the ratio $\frac{R}{R+\bar{r}}$.

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$$e_1 = I R$$
$$e_2 = I \bar{r}$$

Hence $$E = I(\bar{r} + R),$$

and $$\frac{e_1}{E} = \frac{R}{\bar{r}+R}$$

is the ratio of voltage across the ohmic resistance to total voltage, that is, the voltage amplification. This can evidently be made as large as desired by making $\bar{r}$ and R nearly equal, since $\bar{r}$ is negative.

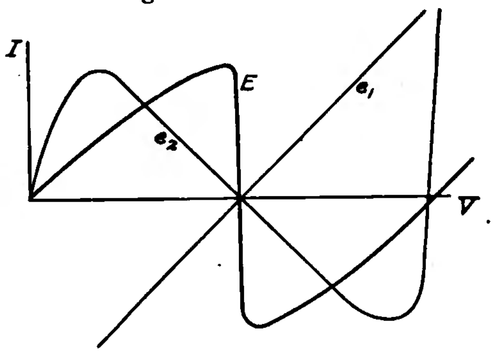


Figure 8

These relations may be clearly seen in the graphical representation of figure 8, where the three curves marked e_1, e_2 and E represent the current-voltage relation in the ohmic resistance, the dynatron, and the total circuit respectively.

With constant batteries, an amplification ratio of 1000-fold can easily be maintained. For example, if R represents a high resistance galvanometer of 2,000 ohms or more, an e.m.f. of 0.01 volt impressed at the terminals of the combination will cause an e.m.f of 10 volts across the galvanometer, with corresponding amplification of galvanometer current.

Further examples and applications of this principle to radio work are given in a later section.

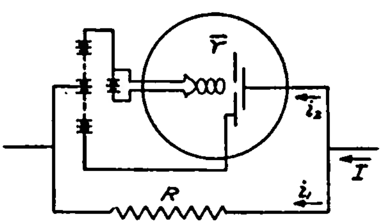


Figure 9

B. Parallel Connection

If the dynatron is connected in parallel with a circuit containing positive resistance, the total conductivity of the circuit, which is the sum of the positive and negative conductivities of its parts, can be made very small. The circuit then acts as a current amplifier. The connections are shown in figure 9. The total current I is the sum of the current i_1 through the positive resistance and i_2 through the dynatron.

Hence $$I = i_1 + i_2 = E\left(\frac{1}{\bar{r}} + \frac{1}{R}\right)$$

$$\frac{i_1}{I} = \frac{\bar{r}}{\bar{r} + R},$$ which may be made very large by making $\bar{r}$ and R nearly equal.

(C) Comm. Pub. Info.

Practice in transmitting information received by wireless from airplanes is afforded daily to our Signal Corps men making ready to go to France. The portable radio set shown can be erected in about a minute and connection by field telephone instantly established with the artillery bases

These relations are shown graphically in Figure 10, where the curves marked i_1, i_2 and I represent the current-voltage relation in the positive resistance, the dynatron, and the total circuit respectively.

The current I to be amplified may be that through a photo-electric cell, a kenotron, or any other non-inductive device the current of which is independent of voltage.

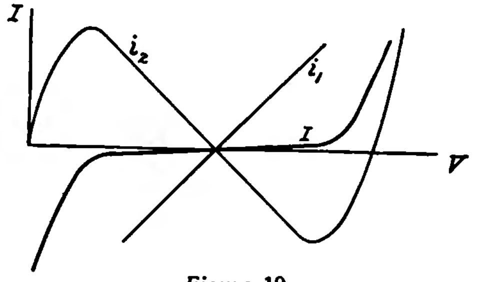


Figure 10

5. Dynatron in Circuit Containing Resistance, Inductance, and Capacity

If the dynatron be left open-circuited, as in Figure 1, it is unstable. This was to be expected as a necessary accompaniment of "negative resistance," and can easily be seen from the current-voltage relation in Figure 3. For when the voltage is greater than that corresponding to the point B, the plate is losing electrons, and hence becoming more positive; and the more positive it becomes, the more rapidly it loses electrons, until the point C is reached. Above C it continues to lose electrons, but more slowly, until it reaches the potential D at which it is in equilibrium. In like manner if the initial potential of the plate is less than B, it will continue to receive electrons until its potential has fallen to 0. At B the plate is in equilibrium, but the equilibrium is unstable, and if slightly disturbed, it will go to 0 or D.

The same instability occurs if the circuit of Figure 1, instead of being left open, is closed through too high a resistance, so that the rate at which the plate receives electrons is greater than the rate at which these electrons can flow away through the resistance. In this case the equilibrium voltages will not be D and 0, but some voltage in the range $D\,C_0$, and $O\,A_0$ respectively. This behavior may be strikingly shown by connecting a voltmeter between filament and plate, and opening the circuit. In this case the stable positions are 0 and a point just below D, and if the plate is originally at B, it will jump to either one or the other of these positions, depending on chance.

If the circuit contains inductance and capacity, as well as resistance, a similar action takes place. The plate charges up through the vacuum, at a rate depending on the capacity and negative resistance, and discharges through the circuit at a rate depending on the inductance and positive resistance. If the inductance is too high, the plate will receive electrons more rapidly than they can flow away through the inductance, and will charge up to some point beyond A or C at which the rate of charge and discharge are instantaneously equal. The inertia of the inductance will then carry it backward toward B, and if the resistance is not too great it will pass through B and oscillate continuously. Whether the circuit will oscillate continuously, or come to rest at B, or come to rest at some other voltage between 0 and D, depends on the relations between inductance, positive and negative resistance, and capacity. These relations can best be given by mathematical analysis, as follows:—

Let the dynatron, with negative resistance $\bar{r}$, be connected in series with a circuit containing inductance, L, resistance R, and capacity C, as shown in Figure 11. Then, calling the instantaneous e.m.f. across either part of the circuit E, we have:

For inductive part of circuit $I = \frac{E}{R} - \frac{L}{R}\frac{dI}{dt}$

For condenser $I + i = -C\frac{dE}{dt}$

For dynatron $i = \frac{E}{\bar{r}} + i_0$

which gives, eliminating E and i,

$$\frac{d^2 I}{dt^2} + \left(\frac{R}{L} + \frac{1}{\bar{r}C}\right)\frac{dI}{dt} + \frac{1}{LC}\left(1 + \frac{R}{\bar{r}}\right)I + \frac{i_0}{LC\bar{r}} = 0$$

the solution of which is

$$I = \frac{i_0}{R+\bar{r}} + A\,\varepsilon^{-\frac{1}{2}\left(\frac{R}{L}+\frac{1}{\bar{r}C}\right)t}\cos\left(\sqrt{\frac{1}{LC} - \left(\frac{R}{2L} - \frac{1}{2\bar{r}C}\right)^2}\;t - a\right) \qquad (1)$$

if

$$\left(\frac{R}{L} - \frac{1}{\bar{r}c}\right)^2 - \frac{4}{LC} < 0$$

and

$$I = -\frac{i_0}{R+\bar{r}} + A\,\varepsilon^{\left[-\left(\frac{R}{2L}+\frac{1}{2\bar{r}C}\right)+\sqrt{\left(\frac{R}{2L}-\frac{1}{2\bar{r}C}\right)^2-\frac{1}{LC}}\right]t} + B\,\varepsilon^{\left[-\left(\frac{R}{2L}+\frac{1}{2\bar{r}C}\right)-\sqrt{\left(\frac{R}{2L}-\frac{1}{2\bar{r}C}\right)^2-\frac{1}{LC}}\right]t} \qquad (2)$$

if

$$\left(\frac{R}{L} - \frac{1}{\bar{r}C}\right)^2 - \frac{4}{LC} > 0$$

where i_0, A, B, a are constants.

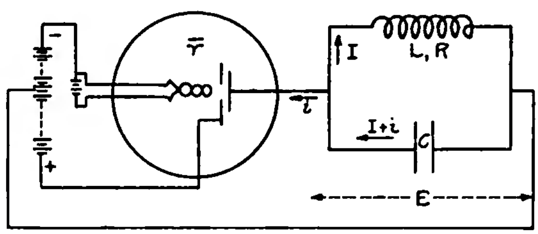


Figure 11

The case of most interest is the oscillatory solution, given by equation 1. This differs from the equation of a simple oscillatory circuit in that the damping factor is decreased from $\frac{R}{2L}$ to $\frac{R}{2L} - \frac{1}{2rC}$, where r represents the positive numerical value of $\bar{r}$, and the period is increased by increasing the damping correction from $\left(\frac{R}{2L}\right)^2$ to $\left(\frac{R}{2L} + \frac{1}{2rC}\right)^2$. It is identical in form with the equation of a circuit containing a leaky condenser, the positive leakage resistance of the condenser being replaced by the negative resistance $\bar{r}$ of the dynatron.

Two oscillatory cases are to be distinguished according as the damping factor is positive or negative. In the first case the circuit is stable, but its damping may be made as small as desired, so that an impressed oscillation will persist for a very long time. In the second case, the circuit will oscillate continuously, with an amplitude that would become infinite if the negative resistance held over an infinite range, and which is therefore limited by the length of the straight portion of the negative resistance curve.

The criterion that the circuit shall generate oscillations is that $\frac{R}{L}+\frac{1}{\bar{r}C}<0$ or, if r denote the positive numerical value of $\bar{r}$, $Rr<\frac{L}{C}$ (3)

In order to test this relation, the inductance L in Figure 11 was made an air-core coil, and a secondary coil in series with a telephone was coupled loosely with it, in order to detect when the circuit was oscillating. With a definite value of negative resistance (determined by a separate experiment from the slope of the current-voltage curve) different capacities were introduced, and the maximum value of positive resistance was determined with which the circuit would still oscillate. The results are given in Table 1.

Table 1

R Ohms	r Ohms	L Henries	C Farads	Rr	L/C
75	3,000	0.689	2.90×10^{-6}	225×10^{3}	237×10^{3}
85	3,000	0.689	2.56×10^{-6}	255×10^{3}	269×10^{3}
96	3,000	0.689	2.26×10^{-6}	288×10^{3}	304×10^{3}
108	3,000	0.689	2.05×10^{-6}	324×10^{3}	334×10^{3}
126	3,000	0.689	1.75×10^{-6}	379×10^{3}	392×10^{3}
158	3,000	0.689	1.41×10^{-6}	475×10^{3}	487×10^{3}
204	3,000	0.689	1.12×10^{-6}	614×10^{3}	615×10^{3}
253	3,000	0.689	0.930×10^{-6}	760×10^{3}	725×10^{3}
78	6.520	0.689	1.27×10^{-6}	510×10^{3}	543×10^{3}
90	6,520	0.689	1.14×10^{-6}	587×10^{3}	602×10^{3}
116	6,520	0.689	0.90×10^{-6}	757×10^{3}	767×10^{3}
162	6,520	0.689	0.636×10^{-6}	$1,060\times10^{3}$	1.080×10^{3}
354	6,520	0.689	0.294×10^{-6}	$2,310\times10^{3}$	$2,340\times10^{3}$
674	6,520	0.689	0.150×10^{-6}	$4,400\times10^{3}$	$4,600\times10^{3}$

According to theory, the maximum value of Rr should be very near to, but always less than $L\div C$. It is seen that this relation is satisfied within the limits of experimental error. The values of Rr are all about 3 per cent. less than $L\div C$, which is the limit set by the sensitiveness of the telephone with the permissible coupling.

The frequency of oscillation is given by the equation

$$n=\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\left(\frac{R}{2L}-\frac{1}{\bar{r}C}\right)^2},$$

in which the bracketed term under the radical is, for most practical circuits, negligible. The range of possible frequencies which can be generated is determined by the above equation, together with the relation (3) between resistance, inductance, and capacity. The limit of radio frequency is set by the minimum value of capacity, positive resistance, and negative resistance, and can be calculated if the distributed capacity and inductance of the coils and connecting wires are known. An ordinary dynatron short-circuited by a couple of turns of heavy wire will give a frequency of about 20,000,000 cycles per second, and it is possible to go continuously from this to a frequency of less than 1 cycle per second by simply changing inductance and capacity.

(To be continued.)

French Official Photo.

Pictures of an actual infantry charge are so rare that special interest is attached to this clear view of the commencement of a heavy patrol fight between French, Serbians and Bulgarians, north of Monastir

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By Captain Fritz E. Uttmark

CHAPTER VII.

Middle Latitude Sailing

IF a vessel sails from a place A to a place B, see figure 1, it is evident that she alters her latitude as well as her longitude and the formulas as given for parallel sailing must be modified. The course and distance from A to B or any two places may be found by Middle Latitude sailing. Solving this problem we need to know the latitude and longitude of the two places. Assuming latitude of A to be 40° 25′ N. and longitude of A 72° 15′ W.; latitude of B, 43° 15′ N. and longitude of B, 70° 30′ W. Proceed thus: Obtain the difference of latitude by subtracting the lesser from the greater if both places have latitudes of the same name, but add if of different names.

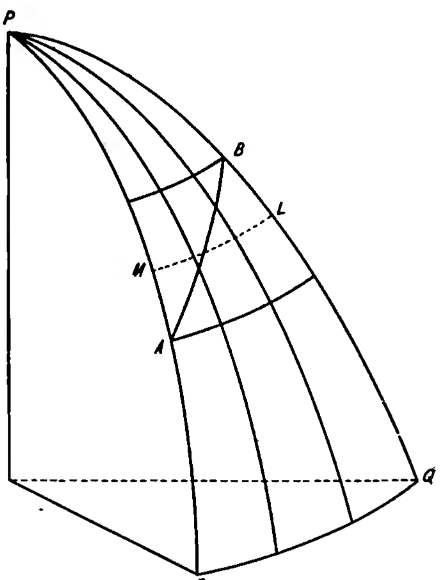


Figure 1

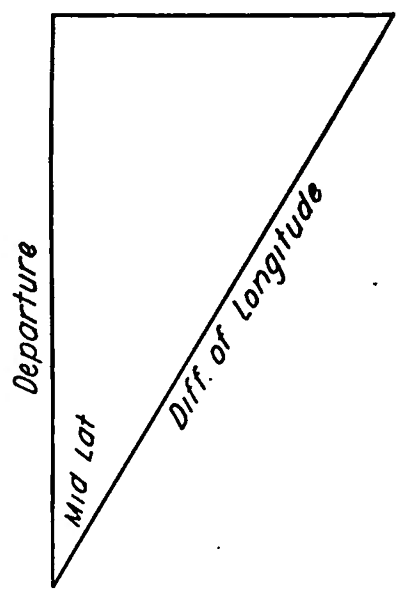


Figure 2

The result will be the difference of latitude expressed in degrees and minutes. Convert this into number of latitude or miles by multiplying the degrees by 60 and adding in the odd minutes.

The difference of longitude is found by addition or subtraction, following the same general rules as for latitude, namely: longitude of same name, subtract, of different names, add; the result is the difference of longitude expressed in degrees and minutes of longitude. Convert this into minutes of longitude by multiplying the degrees by 60 and adding in the odd minutes.

Example:

Lat. A	40° 25′ N.	Long.	72° 15′ W.
Lat. B	43° 15′ N.	Long.	70° 30′ W.
Diff. of Lat.	2° 50′	Diff. of Long.	1° 45′
	x 60		x 60
	120		60
	+ 50		+ 45
Reduced to	170 miles.	Reduced to	105 minutes of longitude

We have here one side of a triangle in miles and the other in minutes of longitude. This cannot be compared unless we convert the difference of longitude into departure or miles. If using the parallel of A (figure 1) for conversion we would on account of the meridians converging towards the pole be using a parallel which would give us too great a number of miles as departure, or using the parallel of B would give us too small a number of miles as departure. There must therefore be a parallel between A and B which used for the conversion would give us the correct result; although not absolutely accurate, this will be midway between the two places or the middle latitude which is found by adding the latitude of A and the latitude of B if of same names, or subtracting if of different names; dividing the result by two gives us the middle latitude.

Lat. A 40° 25′ N.
Lat. B 43° 15′ N.
Dividing by 2) 83° 40′
41° 50′ or 42° nearly.

Having thus found the middle latitude and substituting this for latitude in parallel sailing (see May number of WIRELESS AGE) we proceed exactly according to the rules given there: with the middle latitude of 42° considered as a course and the difference of longitude 105′ as a distance, we find the departure 80.4 in the latitude column. The departure is miles and therefore may be compared with the difference of latitude for finding the course and distance.

Entering Table II with difference latitude 170 and departure 80.4 we find latitude 170.4, departure 79.5, this being the nearest we can find and against this will be found True Course N.25°E. Distance 188 miles.

NOTE: We name the course North because the point of destination B is to the Northward of A and East because the same point is to the Eastward of A.

Example for practice:

What is the true course and distance from A in latitude 40° 25′ N., longitude 74° 00′ W. to B in latitude 32° 10′ N., longitude 64° 50′ W.

Answer, True Course S. 42° E.
Distance 670 miles

Mercator Sailing

In constructing a Mercator's Chart an attempt is made to portray a globular form on a flat surface. The meridians are shown as straight lines parallel to one another and at right angles to the equatorial line or the base of the chart. As the meridians are shown as parallels instead of converging, the chart would show a distorted and very much inaccurate miniature image of the surface of land and sea, unless the latitude scale of the chart is increased in the same proportion as the longitude scale is stretched out in order to allow the meridians to run parallel with one another. This is taken care of in the construction of an increasing latitude scale where each degree or each minute of latitude is a little longer than the preceding one reckoned from the equator towards the poles. The minutes of the Mercator's latitude scale are called *meridional parts* (m.). The values of these are computed and tabulated in Bowditch Table III.

Case I. The course and distance between two points A and B may be measured on Mercator's Chart or be computed according to the formulas given below.

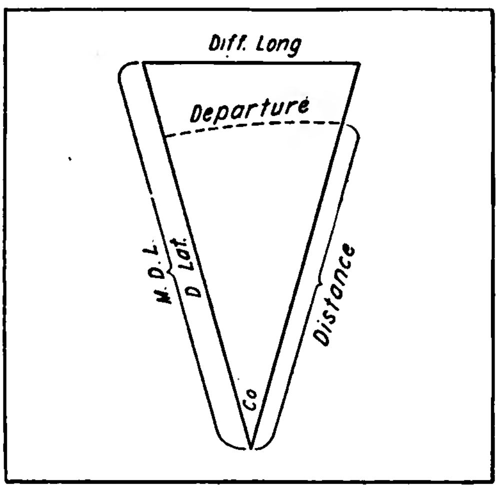


Figure 3

Given latitude A, 36° 40′ N., longitude A, 60° 45′ W.; latitude B, 34° 10′ N., longitude B, 0° 50′ W.—required true course and distance.

Obtain difference of latitude and difference of longitude according to the same rules as for middle latitude sailing. From Table III Bowditch take out the meridional parts corresponding to the latitude of A, also the meridional parts corresponding to the latitude of B. Subtract the lesser from the greater and call the remainder meridional difference of latitude M. D. L.

Lat. A. 36° 40′ N.	m=2353.7	Long. A 60° 45′ W.
Lat. B. 34° 10′ N.	m=2170.4	Long. B 63° 30′ W.
Diff. of Lat. 2° 30′	M. D. L. 183.3	Diff. Long. 2° 45′
x 60		x 60
120		120
+ 30		+ 45
150 miles		165 minutes of longitude.

Find the course according to the formula:

$$\text{Tang C} = \frac{\text{Diff. Long.}}{\text{M. D. L.}} = \frac{165}{183.3} \qquad \begin{array}{r} \log = 12.21748 \\ 2.26316 \\ \hline \log\ \text{tang.}\ 9.95432 \end{array}$$

Answer, True Course S. 41° 59′ 32″ W.

The distance is found according to this formula:

Dist = Diff. latitude secant C
Diff. Lat. 150 log = 2.17609
T. C. 41° 59′ 32″ log Sec = 9.12887

Answer, Distance 201.8 miles 2.30496

Same problem may be solved by inspection.

Look in Table II Bowditch for the M. D. L. (183.3) in a latitude column, search until you find the Diff. Long. (165) in a departure column next to the M. D. L., in this case (found on page 614) 183.6 in the latitude column and 165.3 in the departure column. This being the nearest, we find the course 42° at top of page, and name the course S. 42° W.

Now having found the course, take the number of miles of diff. of latitude and look for same in a difference of latitude column, and the distance will be found in the distance column immediately to the left of the difference of latitude. In this case 150′ being the nearest, the distance is found to be 202 miles; both the course and the distance differ very little from the result obtained by computation.

NOTE: Middle Latitude Sailing may be used to the best advantage when the course is greater than 45° and Mercator Sailing when the course is 45° or less.

The Day's Work

Dead Reckoning is to find the position of the ship by courses steered and the distance run from some point or place, the latitude and longitude of which is known, allowing for known currents, leeway, set of the sea, variation and deviation. The day's work consists of a summing up of courses and distances run during the 24 hours ending at noon on any given day during a voyage and obtaining a fix by Dead Reckoning at noon.

As nearly always a course steered by the ship's compass has to be corrected for its errors, the first part of this problem therefore consists in correcting courses:

Leeway, deviation and variation have been explained in a previous chapter.

The course may be steered using a compass card which is marked in points and quarterpoints. This arrangement is generally used in sailing vessels or smaller steamboats or motor boats where it is more difficult to keep the vessel on an accurate course, or if the compass used has a card of small diameter. Larger vessels have generally a large compass which is divided into degrees. The compass used in merchant ships is divided into four quadrants, having North and South as zero points and East and West named 90 degrees. In the United States Navy the arrangement is different and the compass in general use has a continuous increase of the degrees and reads up to 360°, viz.:—

North being considered zero, East 90°, South 180°, West 270°, completing the circle of 360° again at North.

The table below may be used for converting points into degrees and one system of degrees into another.. The system referred to as used in the merchant marine is generally called the "Old System" and that used in the United States Navy is called the "New System."

Converting Points into Degrees and Vice Versa

Points	Old System	New System	Points	Old System	New System
North	O	O	South	O	180° 00′
N by E	N 11° 15′ E	11° 15′	S by W	S 11° 15′ W	191° 15′
N N E	N 22° 30′ E	22° 30′	S S W	S 22° 30′ W	202° 30′
N E by N	N 33° 45′ E	33° 45′	S W by S	S 33° 45′ W	213° 45′
N E	N 45° 00′ E	45° 00′	S W	S 45° 00′ W	225° 00′
N E by E	N 56° 15′ E	56° 15′	S W by W	S 56° 15′ W	236° 15′
E N E	N 67° 30′ E	67° 30′	W S W	S 67° 30′ W	247° 30′
E by N	N 78° 45′ E	78° 45′	W by S	S 78° 45′ W	258° 45′
East	N/S90°00′E	90° 00′	West	S/N90°00′W	270° 00′
E by S	S 78° 45′ E	101° 15′	W by N	N 78° 45′ W	281° 15′
E S E	S 67° 30′ E	112° 30′	W N W	N 67° 30′ W	292° 30′
S E by E	S 56° 15′ E	123° 45′	N W by W	N 56° 15′ W	303° 45′
S E	S 45° 00′ E	135° 00′	N W	N 45° 00′ W	315° 00′
S E by S	S 33° 45′ E	146° 15′	N W by N	N 33° 45′ W	326° 15′
S S E	S 22° 30′ E	157° 30′	N N W	N 22° 30′ W	337° 30′
S by E	S 11° 15′ E	168° 45′	N by W	N 11° 15′ W	348° 45′
South	O	180° 00′	North	O	360° 00′

Between O and 90° the course is N and E
" 90° and 180° " " " S " E
" 180° and 270° " " " S " W
" 270° and 360° " " " N " W

To Correct a Compass Course

Old System

Assume we stand in centre of compass looking toward the circumference
Apply Westerly Variation to the Left.
" " Deviation " " Left.
" Easterly Variation " " Right.
" " Deviation " " Right.
Leeway for Starboard Tack to the Left.
" " Port Tack to the Right.
The **result** is the **true** course.

New System (360°)

Westerly Variation and Westerly Deviation—Sub (—)
Easterly Variation and Easterly Deviation—Add (+)
Leeway for Starboard Tack—Subtractive (—)
Leeway for Port Tack—Additive (+)
The **result** is the **true** course.

A ship steered the following courses by her compass:

	Compass Course	Wind	Leeway	Dev.	Var.
No. 1	South	W S W	¾ pt.	¼ pt. W	1 pt. W
No. 2	S S W	West	1 "	¼ " W	1 " W
No. 3	S W	N W by W	½ "	¼ " W	1 " W
No. 4	West	S S W	1¾ "	¼ " W	1 " W
No. 5	W by N	N by W	1 "	¼ " W	1 " W

Required the true courses.

Answer No. 1, South; No. 2, S S E ¼ E.; No. 3, S S W ¼ W.; No. 4, W ½ N; No. 5, W S W ¾ W.

(To be continued)

Navigation News

There were 37 steel shipyards in America at the time of our entrance into war. We have located 81 additional steel and wood yards, while 18 other yards have been expanded. Does America realize what this job means? Does it realize what a tribute is paid to its own initiative in this achievement?

The Greatest Maritime Nation

We are building in the new and expanded steel yards 235 new steel ship ways, or 26 more than at present exist in all of the steel ship yards of England. If we had been content with doing the job in a small way, we might have built a few new yards, and added a little to our capacity. A few ships might have been finished more quickly; but it was the spirit and will of America to do the job in a big way, and the judgment of the country will be vindicated by the results when all these new ways are completed and are turning out ships. Many of these ways have actually been finished. The new industry we have created will make America the greatest maritime nation in the history of the world.

It took Germany forty years to build up her military machine. In less than eight months we have built up a shipbuilding machine, which, when it gets into full swing, will defeat the military machine of Germany.

It took Henry Ford, with all his genius for organization and standardization, sixteen years in which to develop his enormous production. It has required twenty years for the United States Steel Corporation to develop its activities to the point where they represent an organization, one-half as large as has been undertaken by the Emergency Fleet Corporation.

☘ ☘ ☘

Hundred Hun Ships for U. S.

The Germans thought that by crippling their own vessels in American waters they would be able to prevent us from using them. American ingenuity and resourcefulness gave the answer by restoring these vessels to efficiency. With the expenditure of a little less than $8,000,000 we have succeeded in placing in our war service and in the service of the Allies 112 first-class German and Austrian vessels representing a carrying capacity of nearly 800,000 deadweight tons.

☘ ☘ ☘

With our total of 730 wood and steel ways, we will have 521 more berths than Sir Eric Geddes in his recent speech stated England has at the present time.

The new method of supplying fuel to destroyers at sea is revealed in this view of an oil hose attached to a tanker

(C) Int. Film Svce.

This remarkable airplane picture, considered by the French to be the greatest ever taken, shows one of the biggest concentration camps at which munitions and men were assembled for the spring drive. Heavy French guns miles away, destroyed the railroad station, but the Germans immediately built another terminal. Here is the official report of the aerial photographer on what the picture shows: 1—Supply railway trains running on newly laid tracks. 2—Piles of supplies, chiefly timbers for use in building dugouts. 3—Rolls of barbed wire. 4—Piles of iron stakes for stringing barbed wire. 5—Steel

roofing for dugouts. 6—Site of railway station before it was destroyed by French shells. Note big shell craters (about sixty feet across) caused by 420 M.M. shells. 7, 8, 9—Remains of former railway tracks where they entered railway station. 10—Broken ties of former railway tracks. 11—Other supplies piled up. Perishable goods covered over with tent cloth. 12—Battery of four guns, with abris for gunners. 13—Commander's dugout. 14—Ammunition park. Note German soldiers standing around. 15—German soldiers standing in the road watching the French airplane.

Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

By Major J. Andrew White
Chief Signal Officer, American Guard

THIRTEENTH ARTICLE

The Wire Company

FUNCTION AND EMPLOYMENT

The wire company is the field signal organization used by the commander of a division for establishing and maintaining those tactical lines of information which radiate from division headquarters, and which serve, in general, to connect these headquarters with the major subordinate units. Normally the wire company is used to connect division headquarters with the headquarters of the various brigades within the division, with the divisional artillery, and, in some cases, with the divisional trains. Opportunity for its use in maintaining communication with the divisional cavalry will occur so rarely that its employment in this manner is prohibited except in emergency.

ORGANIZATION

The wire company is organized into the necessary headquarters and company staff and two platoons of two wire sections each.

For drill the company is formed as above. In the field or on the march the company instrument wagon and the two reserve wire carts form a third platoon under command of the supply sergeant.

The organization, in detail, is as follows:

1 captain.
2 first lieutenants.
1 master signal electrician.
1 first sergeant (sergeant, first class).
1 supply sergeant (sergeant).
1 stable sergeant (sergeant).
1 mess sergeant (sergeant).
1 horseshoer.
1 clerk (corporal).
2 cooks.
1 farrier (corporal).
1 saddler (corporal).
1 mechanic (corporal).
1 assistant mechanic (private, first class).
3 drivers (private, first class).
1 guidon (private, first class).
2 buglers (privates, first class).
4 wire sections.

* The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

A Field Signal Battalion Wire Company, on road for practice

Duties of Individuals

The captain commands the company and is responsible for its training and efficiency.

The lieutenants command platoons, and will be assigned to such other duties as the captain may deem necessary.

The master signal electrician is responsible to the captain for the condition of the technical equipment of the company. To this end he will make frequent and regular inspections of same and, when parts of the technical equipment are found or reported unserviceable, will make or supervise the necessary adjustments or repairs. Under the direction of the captain, he will order such precautionary and corrective measures as he may deem advisable concerning the care and repair of technical equipment. Master signal electricians also act as substitute chiefs of platoons.

The first sergeant is the assistant of the captain, and is responsible to him for the general good order, police, and discipline of the company. In action he remains with the captain and under his immediate orders.

The supply sergeant is responsible to the captain for the care and preservation of the material not issued to the sections.

The stable sergeant is responsible to the captain for the general care of the public animals assigned to the company, the good order and police of the stables and picket lines, and the conduct of the stable personnel, when on duty.

The mess sergeant is responsible to the captain for the efficient and economical handling of the ration, for the conduct of the kitchen personnel when on duty and for the cleanliness of the company kitchen and surroundings.

The mechanics, under the orders of the supply sergeant, are responsible for the repair of the material pertaining to the company.

Chiefs of sections command the sections and will be held responsible to the captain for the condition of their equipment and the training and efficiency of their sections. They will make, or cause to be made, such minor adjustments or repairs to technical equipment as can be effected by the personnel of the section, promptly reporting more serious deficiencies to the master signal electrician.

The drivers are directly responsible to their chiefs of sections for their animals, harness, and equipment. They will report at once to their chief of section any injury to animals or matériel.

Drivers of combat vehicles not assigned to sections are likewise responsible to the supply sergeant.

The operators are responsible for the serviceable condition of their instruments and will report at once to their chiefs of sections any need of repairs.

The linemen are responsible for maintaining the section lines intact. They will carry the necessary equipment, and will report to the chief or section at once if their matériel is not in their possession or is unserviceable.

Messengers are responsible for the delivery of all messages, no matter what the conditions.

The Section

Composition

The wire section is normally composed of 13 mounted men and a wire cart and its driver.

The organization, in detail, is as follows:

1 section chief (sergeant, first class).
1 driver (private, first class).
3 station squads, each consisting of:

1 lineman 1 messenger 1 horse holder 1 operator Total, 14.	assigned by section chief from sergeant, corporal, private, first class, or private according to qualifications.

Formation

The mounted men of the section are formed in column of fours, as prescribed in The Soldier Mounted, the cart horses 2 yards in rear of the mounted men, and in such a position that the pole of the cart is in prolongation of the interval between the numbers 2 and 3 in the mounted ranks.

Posts and Duties of Individuals

The chief of section is on the left of the leading four, two or file, except that when the section is acting alone he may go where his services are most needed.

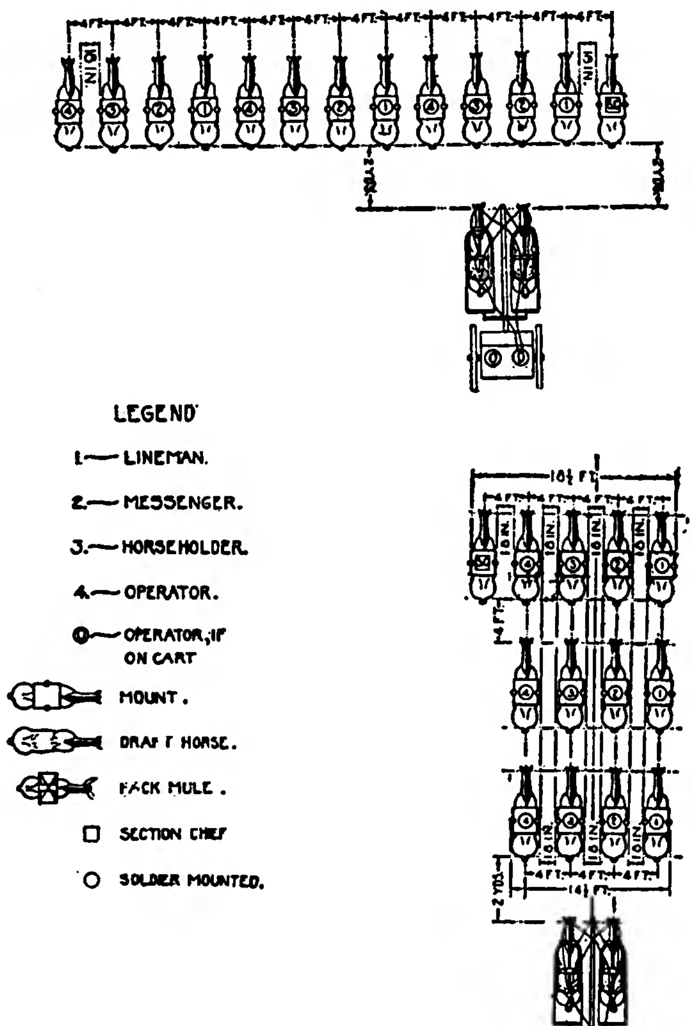
Each four constitutes a *station squad* and includes the personnel necessary to establish and operate one buzzer station. Each four is formed from right to left as follows: No. 1, the lineman; No. 2, the messenger; No. 3, the horse holder; No. 4, the operator.

Where practicable, noncommissioned officers, except the chief of section, should be assigned to duty as operators.

To Open Station

To open station and move to the front from a halt: OPEN STATION. At this command the lineman of the first and second fours, the messenger of the first four, and the chief of section turn out of the column, to the right, the horse holder and operator of the first four turn out of the column to the left. The two linemen, remaining mounted, prepare to follow the reel cart and lay out the wire, the lineman of the second four starting off in front.

The remaining men of the first four all move to the rear of the cart and dismount, except the horse holder, to whom the horses are turned over. The



THE WIRE SECTION
ABOVE—SECTION IN LINE
TO THE RIGHT—SECTION IN COLUMN

messenger unties the wire from the cart and pulls off enough slack and holds it or makes it fast to some convenient anchor. The operator prepares his buzzer, connectors, and ground rod, and opens the station in the location indicated.

When it becomes necessary for the lineman of the second four to stop for the purpose of making a tie, or for other reasons, he is passed or "leap frogged" by the lineman of the first four. This practice obtains whenever two linemen are working together, linemen using the "leap frog" method to the best advantage.

Laying the Wire

When the end of the wire has been removed from the cart the chief of section, or, in his absence, the senior present, at a signal from messenger, commands: DRIVE ON, at which command the cart, preceded by the men of the second and third fours, except the lineman of the second four, moves out over the indicated route; at first slowly, in order not to break the wire. The two linemen follow the cart attending the wire until the second station is opened, when the lineman of the first four returns back over the line to his station. His place is taken on the line work by the lineman of the second four, who is replaced by the lineman of the third four.

The manipulation of the machinery of the wire cart for handling the wire will be a part of the duty of the cart driver, unless an operator be placed on the cart, in which case the latter may handle the clutch. The reel must always be stopped before a march to the rear is taken up.

The chief of section rides near the cart, or wherever necessary in order to properly supervise the laying of the line. He will also designate a scout to precede the section from 100 to 200 yards and select a route in the immediate front for the cart to follow. The driver will conform to the signals of the scout. If the section is in march, it is halted before giving the command for opening station. As each station is established the operator will call up the initial station.

To Close Station

CLOSE STATION. At this command the lineman of the distant station immediately starts back over the line, laying out the wire in a convenient place for recovery. The operator of the distant station calls up all stations on his line, send G. B., and signs his station call, cuts out his buzzer, and mounts. The horse holder now mounts and prepares to attend the loop, using the spare pike which is lashed to the pole of the wire cart. The messenger takes the hand guard from the cart and feeds the wire upon the reel.

Recovering the Wire

REEL UP. At this command the wire cart moves off back over the line, reeling up the wire. As the loop approaches the cart the man attending it will call out *clutch,* when the driver will throw out the clutch in order to allow the loop to drop back.

Intermediate stations are closed by the command *close station,* and when the cart approaches the members of these stations take charge of the work of recovering the line back to the next station.

Members of the section not engaged in laying out or recovering the line ride in front of the cart. *This rule is general.*

As the cart approaches the end of the line an increased gait will be taken to gain sufficient momentum to reel up the slack. When all the wire is on the reel the section is re-formed in its proper place.

The Wire Platoon

Composition

The wire platoon is composed of two wire sections and is commanded by a lieutenant.

Formation

The habitual formations of the platoon are the *order in section column* and the *order in line.*

(C) Comm. Pub. Info.

This glimpse of Americans in France gives a clase view of a communicatian trench of the Signal Corps with Major General Menoher and staff emerging after an inspectian, news of his arrival being wig-wagged by the signalmen in the middle distance

A Field Signal Battalion laying the wires of communication along a road

The *order in section column* is that in which the sections of the platoon follow each other in the order, or the reverse order, of their numbers from front to rear. The distance between sections is 2 yards.

The *order in line* is that in which the sections of the platoon are formed abreast of each other in the order, or the reverse order, of their numbers from right to left. The interval between the sections is that which would result from the sections moving from the order in section column by the flank. This interval is approximately 16 yards.

Posts and Duties of Individuals

In the order in section column the post of the lieutenant is 4 yards opposite the center of the platoon, on the left when the first section of the platoon is leading and on the right when the column is reversed. In the order in line his post is midway between the two sections and in line with the leading fours of the platoon. When acting as an instructor he goes where his presence is necessary.

The lieutenant commands the platoon. The posts and duties of enlisted men in the platoon are prescribed in section II above.

Drill of the Platoon

The platoon is drilled in accordance with the principles and by the methods and means prescribed for the section and the company.

The captain may assign to platoons, for purposes of drill and instruction, such members of the company staff as he may deem advisable.

Signal Corps News

The Provost Marshal General has sent the following telegrams to the governors of all States:

Enlistment of Students of Electrical Engineering

Notify all local boards of the following amendment to section 151, Selective-Service Regulations. An additional sub-paragraph is added to paragraph "e" as follows:

"Under such regulations as the Chief Signal Offiçer may prescribe, a proportion of the students in institutions in which the Signal Corps has established a course in electrical communication, who have completed at least 2½ years of the course in electrical engineering, or its equivalent, in one of the approved technical engineering schools listed in the War Department, may enlist in the Signal Enlisted Reserve Corps, and thereafter, upon presentation by the registrant to his local board of a certificate of such enlistment, such certificate shall be filed with the questionnaire and the registrant shall be placed in Class 5 on the ground that he is in the military service of the United States." Acknowledge.

CROWDER.

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Detailed Temporarily as Majors

By direction of the President the following-named officers, who hold the grade of major by reason of their having passed their junior military aviator or junior military aeronaut examination, are detailed in the Signal Corps temporarily as majors under the provision of the act of Congress approved July 24, 1917: Capts. Guy L. Gearhardt, John N. Reynolds, James L. Dunsworth, Delos C. Emmons, Arnold N. Krogstad, Thomas S. Bowen, Jack W. Heard, Claud K. Rhinehart, Tolbert F. Hardin, Arthur Boettcher, Bert M. Atkinson, Ira A. Rader, Leo G. Heffernan, Douglas B. Netherwood, Patrick Frissel, George H. Brett, Lewis H. Brereton, Edward L. Hoffman, Norman W. Peek, James R. Alfonte, Leslie MacDill, Paul L. Ferron, Lawrence S. Churchill, George E. A. Reinburg, Martin F. Scanlon, Davenport Johnson, Millard F. Harmon, jr., Thorne Deuel, jr., Shepler W. Fitz Gerald, Arthur R. Christie, John C. McDonnell, Roy S. Brown, John B. Brooks, John C. P. Bartholf, Harold M. Clark, Richard B. Barnitz, Harold S. Martin, Earl L. Canady, Clinton W. Russell, George E. Lovell, jr., George W. Krapf, Howard C. Davidson, Maxwell Kirby, Harvey B. S. Burwell, John W. Butts, Walter W. Wynne, William A. Robertson, Carl Spatz, Warren P. Jernigan, Benjamin G. Weir, Ralph Royce, William O. Ryan, Harry M. Brown, Sheldon H. Wheeler, Clinton W. Howard, Joseph T. McNarney, Edwin B. Lyon, Charles C. Benedict, John E. Rossell, Earl L. Naiden, Whitten J. East, Michael F. Davis, Hubert R. Harmon, Harry B. Anderson, Norman J. Boots, George Pulsifer, jr., Thomas J. Hanley, jr., Leo A. Walton, Ralph P. Cousins, Adlai H. Gilkeson, George E. Stratemeyer, and William B. Peebles.

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Appointments in the Officers' Reserve Corps

The following appointments in the Officers' Reserve Corps and National Army have been made in the Office of The Adjutant General. The officers whose names appear in this list, if they have not already done so, should telegraph acceptance of commissions to The Adjutant General, Washington, D. C. The telegrams should be signed with full name and rank.

To be captain, Aviation Section, Signal Reserve Corps:

Harold A. Wise, 301 Richmond Avenue, San Antonio, Tex.

To be first lieutenant, Aviation Section, Signal Reserve Corps:

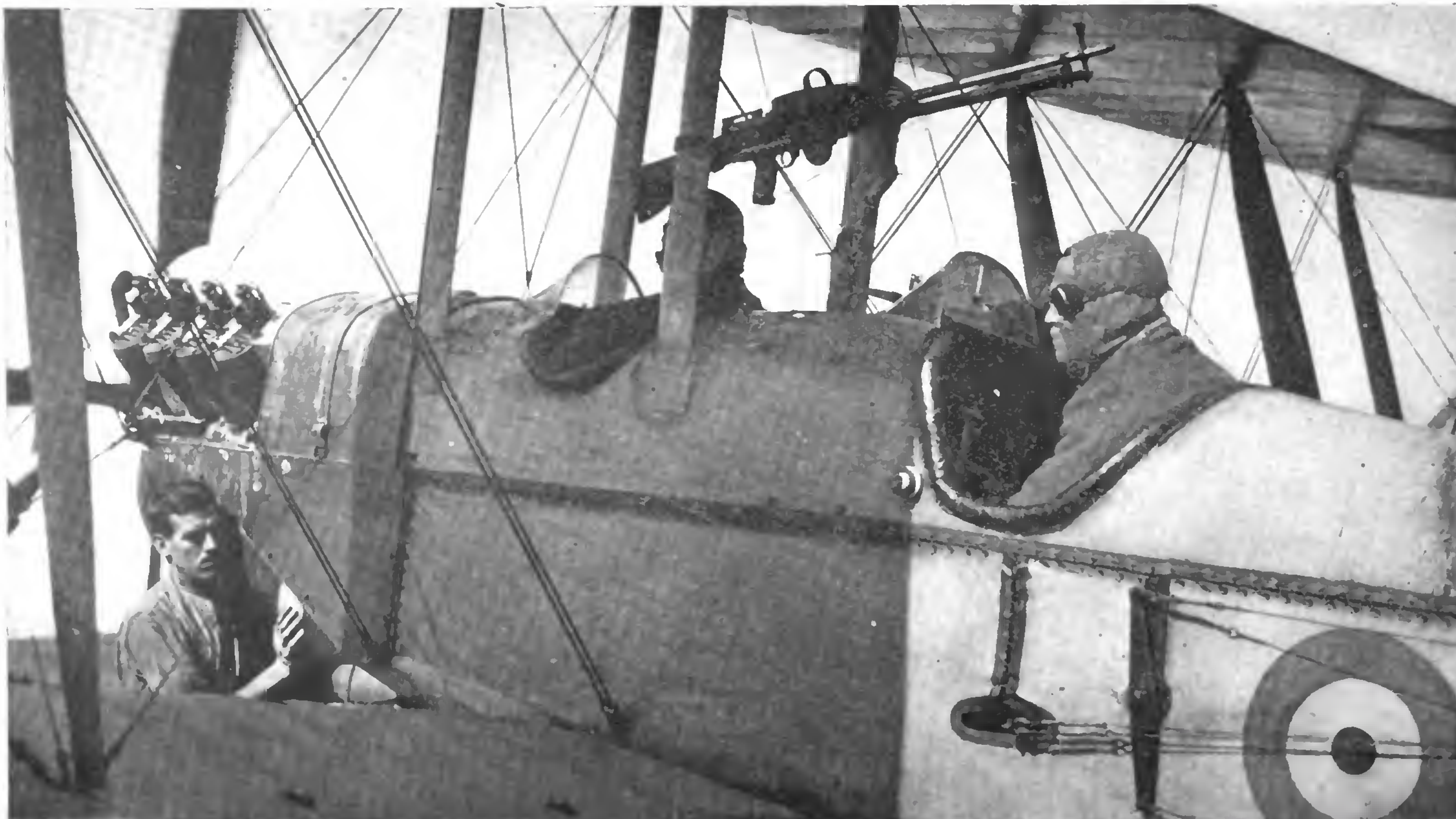
George W. Harvey, Camp Meade, Md.

To be second lieutenants, Aviation Section, Signal Reserve Corps:

Ohio State University, Columbus.—Sawnie R. Aldredge, Orlando B. Black and Thomas E. Nelson.

Georgia School of Technology, Atlanta.—Nelson H. Bedell, Walter K. Blanton, Fred J. Bolender, Ross Boothe, Robert H. Brown, Shermer D. Brunt, Clyde H. Carley, John F. Clark, Howard E. Cook, Harry S. Covington, Allan H. Crary, George A. Crocker, jr., Elmer F. Gegon, Donald M. Dey, Agnew T. Dice, jr., Rutherford Fleet, Nathan K. Gallinger, Edward W. Garnier, Rob R. George, Le Moyne R. Graham, Hubert G. Haller, Clyde M. Hamilton, Clark H. Hogan, Edward R. Kelly, Louis W. Kemp, Erick J. Kunkel, Bernard W. Lee, Raymond P. Luce, John B. McCormick, John E. McGraw, George B. Matthews, jr., Leland H. Merrill, Paul L. O'Reilly, James W. Rader, Max L. Rafeld, Erwin T. Ridgeway, Benjamin M. Schulein, Alfred C. Scott, Allan D. Shackleton, Fred M. Shields, Louis J. Shoemaker, James M. Slaughter, Herbert A. Stoddard, Gordon C. Thorne, Joseph T. Trotter, George B. Wallace, Charles B. Warner, Edward S. Winfree, Paul C. Yount.

To be first lieutenant, Aviation Section, Signal Corps, R. A. T. Edmund, A. Kruss, San Diego, Cal.

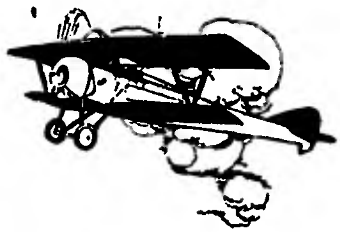


(C) Int. Film Svce.

The trim ossembly of the modern wor airplone may be noted from this view of a British two-seoter, speciol interest ottoching to the convenient suspension of the Lewis mochine gun overheod ond the air-cooled 8-cylinder V-motor with 4-blode propeller

How to Become an Aviator

The Eleventh Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By Henry Woodhouse

Author of "Text Book of Naval Aeronautics"

SUPPLEMENTAL to the description and definition of function of valves contained in the May issue, the student of this series will find a knowledge of valve setting and valve timing of value. Instruction in these two operations, as officially given for the Curtiss engine, follow:

Valve Setting—After grinding and cleaning, set the inlet valves at 0.010 clearance and the exhaust valves at 0.010 clearance. This setting should be done on each cylinder just after inlet valve has closed. If the stem is indented due to any cause, remove the valve and grind the stem end to a flat surface.

Valve Timing—After setting the clearance, turn the engine in the direction of rotation till the piston of No. 1 cylinder is 1/16 inch past top center. Then turn the camshaft in its direction of rotation till the exhause valve No. 1 cylinder has just closed. Put on the camshaft gear, being sure that the keyway of the gear lines up with the key in the camshaft.

Thus set and timed, the inlet valves will open 12 degrees past top center and close 40 degrees past bottom center; the exhaust valves will open 45 degrees before bottom center and close on top center.

As it is now purposed to consider ignition and its relation to the efficient operation of the aviation engine, these further practical suggestions on timing may well be included.

Magneto Timing—Turn the engine in the direction of rotation till the intake valve of No. 1 cylinder has closed; then turn the engine in the same direction till the piston of No. 1 cylinder is on top dead center; then turn the motor backward till the piston of No. 1 cylinder is ½ inch from top center. Turn the armature of the magneto in the direction of its rotation (it is the same as that of the crankshaft) till the distributor brush is on No. 1 segment with the breaker points just ready to open. Put on the magneto gear, using the same precaution as given for engaging the camshaft gear. This should bring the firing-time of all cylinders to 30 degrees before top center.

The spark advance lever should be in position of full advance during this whole operation. The gap between the breaker points should be 0.018 inch and that of the spark-plug points 0.023 inch.

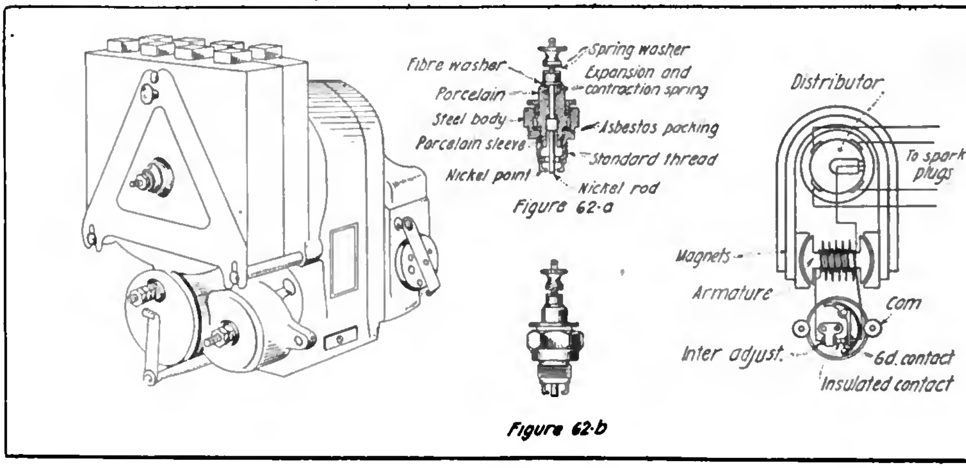


Figure 61—A high tension magneto

Figure 62a—Construction of spark plug
Figure 62b—General view of spark plug

Figure 63—Construction of the magneto

IGNITION

To set afire the compressed gas mixture in the cylinder at the proper time an electric spark is produced in the combustion chamber, through the medium of a spark plug the points of which offer a break in the ignition circuit, causing the current to jump the gap and spark. The essentials of an ignition system for aviation engines are, (a) a method of producing the current, (b) timing apparatus to regulate the sparking at the proper instant in each cylinder, (c) wiring and auxiliary devices to carry the generated current to the spark plug in the cylinder.

MAGNETO

Aviation motors are equipped with high-tension magnetos, i.e., those with a secondary winding of fine copper wire over the primary winding, as distinguished from the low-tension type with primary coil only. In the coarse wire winding, or primary (on top of which is the secondary winding of fine wire) a low-tension current is generated as the armature revolves between the ends of the magnets. This low-tension current then flows to the circuit breaker, where it is broken by the points operated by a cam. The current then goes to a condenser for storage until the points again close. Breaking the current creates a high-tension current which flows to the distributor and spark plugs.

Figure 61 shows the Berling high-tension magnetos, used on Curtiss engines and one of the best of the representative types; figure 63 shows the construction.

DISTRIBUTOR

The distributor is the device wherein both the primary and secondary currents generated by the magneto are collected by a brush and distributed to the proper cylinder at the proper time.

CONDENSER

Absorption of the self-induced current of the primary winding, thereby preventing it opposing the rapid fall of the primary current, is the function of the condenser.

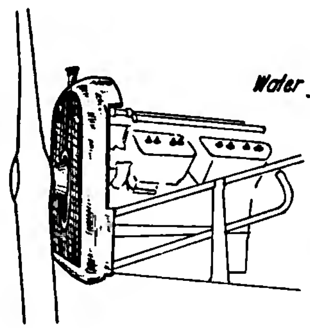
CIRCUIT BREAKER

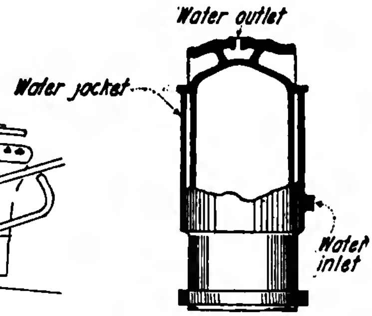
This device keeps the circuit closed except at the time of sparking.

SPARK PLUG

This device consists of an insulating member screwed into the cylinder and carrying the terminal electrodes across which the spark for ignition jumps. The secondary wire from the coil is attached to a terminal at the top of the central electrode. Details of construction of the spark plug are shown in figures 62a and 62b.

Spark plugs are screwed into the combustion chamber directly in the path of the incoming gases from the carbureter. On most aviation engines a double set of plugs is used, two to a cylinder, igniting the mixture at two different points and thereby gaining twenty-five per cent motor power at high speed.





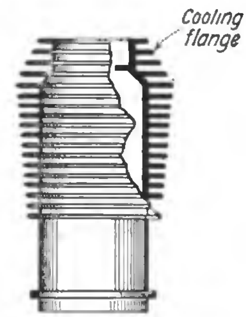


Figure 64—Radiator at front of fuselage *Figure 65a—Water cooled cylinder* *Figure 65b—Air cooled cylinder*

COOLING

The intense heat of the explosions in engine cylinders would heat the metal portions to a point where the lubricating oil would be burned and become useless and the piston rings expand and bind in the cylinder walls, if a means of cooling was not provided. There are two general systems of cooling: (a) water cooling; (b) air cooling.

WATER COOLING

This system consists of a circulation of water through jackets which surround the heated portion of the cylinder wall; a radiator, constructed of thin metal tubes with a large exposed surface area, wherein the water is cooled; and a means of keeping the water in circulation from the cylinder jackets to the radiator, and back again through the system.

Figure 64 illustrates one form of radiator, constructed at the front of the fuselage with provision for the propeller hub.

Figure 65-a is a view, partly in section, of a cylinder with water jacket cast integral.

The water is circulated either by a pump which is gear-driven from the motor, or it is automatically circulated by the thermo-syphon principle, which utilizes the tendency of heated water to rise.

When the airplane is at its angle of steepest climb maximum heating of the motor occurs. For this reason, radiators are constructed so the cells are not horizontal, but parallel to a tangent of the mean trajectory of climb.

AIR COOLING

Cooling flanges or metal fins are radiated from the cylinder walls in the air-cooled type of engine; to absorb the heat of the explosions and diffuse it in the rush of air. The cylinders are placed directly in the path of the propeller slip stream and often a powerful fan is used to increase the rate and degree of cooling.

Figure 65-b shows an air-cooled cylinder, partly in section.

The principal advantage of air cooling is reduction of weight through the elimination of the various parts of the water cooling system. Rotary radial cylinder types have proved practical with air cooling, but it is generally conceded that the water-cooled motor is best for long flights.

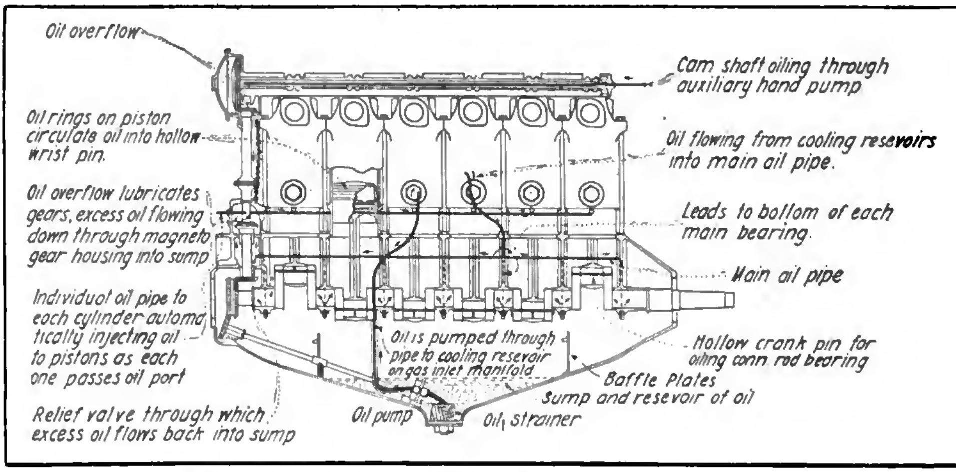


Figure 66—A modern oiling system for aviation engines

LUBRICATION

The necessity for providing some means of preventing excessive friction between swiftly moving parts is due to the heating which would result if a lubricant was not applied between them. The temperature of the aviation engine as a whole is an additional reason for insuring proper oiling of parts.

Two types of motor lubrication are in use:

(a) Splash lubrication—Oil is held in the sump, or reservoir at the bottom of the crankcase, and splashed on the moving parts by the revolutions of the crankshaft.

(b) Force-feed—Positive mechanical means deliver the oil under pressure to the various working parts of the engine.

Owing to the evolutions of the aeroplane in flight lubricating systems have been elaborated to deliver oil as needed to all working parts and to eliminate the possibility of flooding cylinders.

FORCE-FEED LUBRICATION

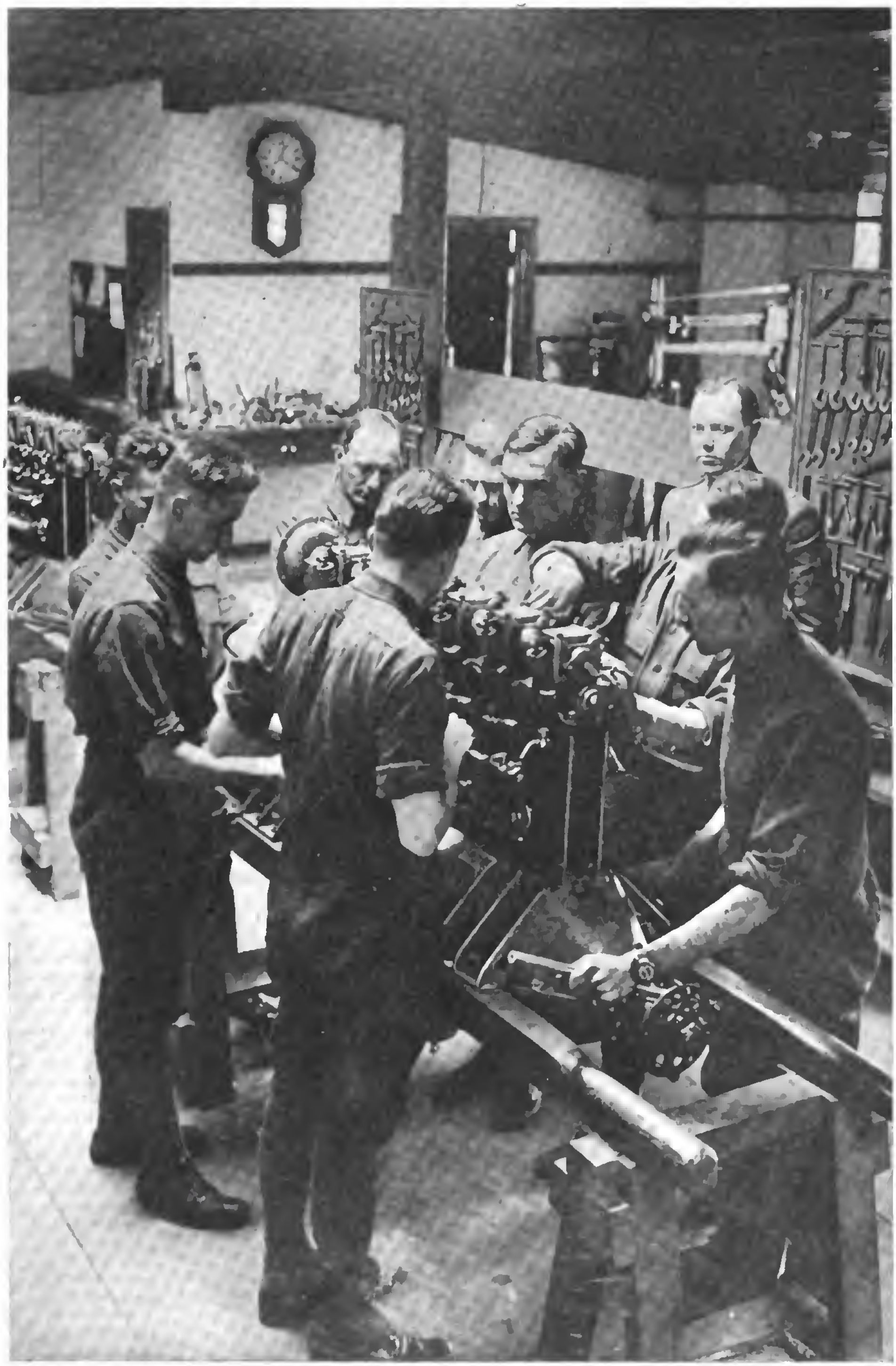
Figure 66 gives a clear illustration of a modern oiling system for aviation engines; in this instance, the Hall-Scott engine, selected as representative of the best practice in lubrication.

The crankshaft, connecting rods and all other parts within the crankcase and cylinders are lubricated directly or indirectly by a forced-feed oiling system. The cylinder walls and wrist-pins are lubricated by oil spray thrown from the lower end of the connecting rod bearings. The oil is drawn from the strainer located at the lowest portion of the crankcase, forced around the main intake manifold jacket. From here it is circulated to the main distributing pipe located along the lower left hand side of the upper portion of the crankcase. The oil is then forced directly to the lower side of the crankshaft, through holes drilled in each main bearing cup. Leakage from these main bearings is caught in scuppers placed upon the cheeks of the crankshaft furnishing oil under pressure to the connecting rod bearings.

A bi-pass located at the front end of the distributing oil pipe can be regulated to lessen or raise the pressure. By screwing the valve in, the pressure will raise and more oil will be forced to the bearings. By unscrewing, pressure is reduced and less oil is fed.

Independent of the above-mentioned system, a small, directly driven rotary oiler feeds oil to the base of each individual cylinder. The supply of oil is furnished by the main oil pump located in the lower half of the crankcase. A small sight-feed regulator controls the supply of oil from this oiler. This instrument is placed higher than the auxiliary oil distributor itself to enable the oil to drain by gravity feed to the oiler.

The oil sump plug is located at the lowest point of the crankcase. This is a trap for dirt, water and sediment and is removed by unscrewing. Oil is furnished mechanically to the camshaft housing under pressure through a small tube leading from the main distributing pipe at the propeller end of the engine directly into the end of the camshaft housing. The opposite end of this housing is amply relieved to allow the oil to rapidly flow down upon camshaft, magneto, pinion-shaft, and crankshaft gears, after which it returns to the lower crankcase. An outside overflow pipe is also provided to carry away the surplus oil.



(C) Comm. Pub. Info.

Student aviators of the Signal Corps, U. S. A., learning in the ground school how valves are adjusted and ignition timed on aeronautic motors

IMPORTANT DON'TS

Don't forget to inspect the motor thoroughly before starting.

Don't try to start without oil, water, or gasoline; all three are vital.

Don't forget to see that the radiator is full of water.

Don't get dirt or water into the oil.

Don't get dirt or water into the gasoline.

Don't forget to oil all exposed working parts.

Don't try to start without retarding the magneto; a serious accident may result.

Don't try to start without turning on the switch.

Don't start the motor with throttle wide open.

Don't run the motor idle too long; it is not only wasteful but harmful.

Don't forget to watch the lubrication; it is most essential.

Don't forget that the propeller is the business end of the motor; treat it with profound respect—especially when it is in motion.

Don't cut off the ignition suddenly when the motor is hot; allow it to idle for a few minutes at low speed before turning off the switch. This insures the forced circulation of the water till the cylinder walls have cooled considerably and also allows the valves to cool, preventing possible warping.

Don't fail to study the trouble chart before you molest a thing about the motor, if you have trouble.

Don't develop that destructive disease known as tinkeritis; when the motor is working all right, let it alone.

Don't forget a daily inspection of all bolts and nuts. Keep them well tightened.

Don't fail to stop your motor instantly upon detecting a knock, a grind, or other noise foreign to perfect operation. It may mean the difference between saving or ruining the motor.

THE TROUBLE CHART

Based on Curtiss engines, this chart has been prepared to outline in a simple manner the various troubles that interfere with the efficient action of aeronautical motors.

Defects that may develop are tabulated for ready reference, and opposite the part affected the various conditions are found under a heading that denotes the main trouble to which the others are contributing causes.

The various symptoms denoting the individual troubles outlined are given to facilitate their recognition in a positive manner. Brief note is also made of the remedies for the restoration of the defective part or condition.

It is apparent that a chart of this kind is intended merely as a guide, and it is a compilation of practically all the known troubles that may materialize in gas-engine operation. While most of the defects outlined are common enough to warrant suspicion, all will never exist in an engine at the same time; and it will be necessary to make a systematic search for such of those as do exist, and by the process of elimination locate the offending part.

To use the chart advantageously it is necessary to know and recognize easily one main trouble. For example, if the motor is skipping, look for possible troubles under the heading "Skipping." If the motor fails to develop power, the trouble will undoubtedly be found under "Lost Power and Overheating."

It is assumed in all cases that the trouble exists in the power plant or its components, and not in the auxiliary members of the ignition. In many instances, however, the seat of trouble will be traced to these latter members.

SKIPPING OR IRREGULAR OPERATION

PART AT FAULT	TROUBLE	EFFECT	REMEDY
Spark plug	Loose binding at post Leak in threads Defective gasket Cracked insulator Points too close Points too far apart Carbon deposit Plug too long	No spark Low compression Low compression Short-circuit No spark No spark No spark Pre-ignition	Tighten terminal Screw down tighter Replace with new plug Replace with new plug Set points apart Set points closer Clean off points and plug Change plug
Combustion chamber	Carbon deposit	Pre-ignition	Remove carbon
Piston head	Carbon deposit Crack or blowhole (rare)	Pre-ignition Pre-ignition	Remove carbon Replace with new
Valve head	Warped or pitted on seat	Poor mixture Low compression	True up in lathe and grind to seat Replace with new
Valve stem	Binds in guide sticks	Irregular valve action	Clean guide Straighten stem Oil
Valve spring	Weakened or broken	Irregular valve action	Replace with new
Exhaust valve seat	Scored or warped Dirty or covered with scale	Valve will not close Poor mixture Poor compression	Use reseat reamer Clean off and grind to seat
Exhaust valve-stem guide	Warped or carbonized Worn guide	Valve stem sticks Low compression Poor seating Poor mixture	Clean guide or new guide
Valve-stem clearance	Too little Too much	Valve will not shut Valve opens late and closes early	Set inlet gap 0.010 Set exh. gap 0.010
Camshaft bearing	Looseness or wear	Valves mistimed or valve lift short	Replace with new bushing
Cam	Worn contour	Valve lift short Valves mistimed	Replace with new camshaft
Timing gear	Not properly meshed Loose on shaft Worn or broken tooth	Valves mistimed Valves do not act	Time properly Fasten to shaft with key Replace with new gear
Cam-follower guide	Loose on engine base Lock pin sheared off Worn in bore	Oil leaks Poor valve action	Fasten securely New pin New guide or bushing
Cam follower	Loose in guide	Valves mistimed Oil leaks	Replace with new guide or bushing
Inlet valve	Closes late Opens early	Blowback in carbureter	Time properly
Inlet-valve seat	Warped or pitted Does not seat properly Carbon grain under seat	Blowback in carbureter Low compression	Use reseat reamer Clean off and grind to seat
Inlet-valve stem guide	Worn	Poor mixture Low compression	Bush or replace with new guide
Carbureter	Weak mixture	Blowback in carbureter	Adjust carbureter for richer mixture
Gas manifold pipe	Leak at joints Defective gasket Crack or blowhole	Poor mixture Poor mixture Poor mixture	Stop all leaks Replace with new Solder blowhole
Piston	Walls scored	Poor suction and leak of gas	Smooth up
Piston rings	Loss of spring Loose in grooves Worn or broken Slots in line	Poor suction and leak of gas Poor compression	Peen rings or replace with new Loosen rings on piston
Cylinder Wall	Scored by wristpin Scored by lack of oil	Poor suction and leak of gas Poor compression	Lap in cylinder Or new cylinder
Valve-spring collar key	Broken	Release spring No valve action	Replace with new key

LOST POWER AND OVERHEATING

Part at Fault	Trouble	Effect	Remedy
Manifold connections	Poor mixture in one set of cylinders with good mixture in other set	Surging or pulsating	Tighten connections; put in new gaskets
Water-pipe joint	Loose Defective gasket	Loss of Water and over-heating	Tighten bolts or replace with new connection
Spark plug	Loose in threads Defective gasket	Poor compression and overheating	(See Spark Plug under "Skipping") Screw down tight Replace with new
Combustion chamber	Crack or blowhole Roughness Carbon deposit	Poor compression Pre-ignition Pre-ignition	Fill by welding or replace with new Smooth up Remove carbon
Valve-head	Warped, scored, or pitted Carbonized or covered with scale	Poor compression	True up in lathe and grind to seat Scrape off smooth with emery cloth
Valve seat	Warped or pitted Carbonized or covered with scale	Poor compression or blowback	Use reseat reamer Clean off and grind to seat
Piston rings	Loss of spring Loose in groove Worn or broken Slots in line	Poor suction, leak of gas, and over-heating Poor compression	Peen rings or replace with new Loosen rings on piston
Piston rings	Broken because too tight Insufficient opening	Scored cylinder walls, overheating in sump pan, and poor compression	Replace scored cylinder if groove is deep; use new rings
Wristpin	Loose Scored cylinder	Poor compression	Fasten securely Replace scored cylinder if groove is deep
Piston head	Carbon deposit Crack or blowhole (rare)	Pre-ignition Poor compression	Remove carbon Replace with new
Piston	Binds in cylinder Walls scored or worn out of round	Overheating	Lap off excess metal Replace with new
Cylinder wall	Scored Poor lubrication causes friction	Poor compression and overheating	Replace with new Lap in cylinder Repair oiling system
Camshaft Drive gear	Loose on shaft Not properly meshed Worn or broken teeth	Irregular valve action	Fasten to shaft Time properly Replace with new
Crankshaft	Scored or rough on journals Sprung	Overheating Overheating	Smooth up Straighten
Crankpin Bearings and main bearings	Adjusted too tight Defective oiling	Overheating	Adjust to running clearance Clean out oil holes
Oil sump	Insufficient oiling Poor oil Dirty oil	Overheating and burned-out bearings	Replenish supply Use best oil—Mobile "A" recommended Wash with kerosene Replace with new oil
Water space and water pipes	Clogged with sediment or scale	Overheating	Dissolve and remove foreign material
Radiator hose	Layer of hose obstructs opening	Overheating	Refit or replace with new
Water pump	Impeller loose on shaft Dirty Broken	Overheating	Fasten to shaft Clean Replace with new

NOISY OPERATION

PART AT FAULT	TROUBLE	EFFECT	REMEDY
Spark plug	Leakage	Hissing	Screw down tighter Replace with new
Cylinder wall	Scored	Knocking	Smooth up or replace with new
Manifold pipe joints	Leakage Defective gaskets	Sharp hissing	Tighten bolts Replace with new
Combustion chamber	Carbon deposit	Knocking	Remove carbon
Cylinder casting	Retaining bolts loose	Sharp metallic knock	Tighten bolts
Cam	Worn contour	Metallic knock	Replace with new
Piston head	Carbon deposit	Knock	Remove carbon
Wristpin	Loose in piston Worn	Dull metallic knock	Replace or bush
Connecting rod	Worn at wristpin or crankshaft Sideplay in piston	Distinct knock	Adjust or replace Scrape and fit and oil
Main crankshaft bearing	Loose Defective lubrication	Metallic knock Squeak	Fit caps close to shaft Clean out oil holes and oil
Connecting-rod bearings	Loose Excessive play Binding	Intermittent metallic knock Knock and squeak	Refit Reline
Connecting-rod bolts, main-bearing bolts	Loose Stripped threads	Sharp knock	Tighten Replace bolts
Lower half Crank-case bolts	Loose Stripped threads	Knock and rattle	Tighten New bolts
Water jacket	Covered with scale Clogged with dirt	Knock caused by overheating	Dissolve scale and flush out water space with water under pressure
Timing gears	Loose Worn or broken teeth Meshed too deeply	Metallic knock Rattle Grinding	Fasten to shaft Replace with new gear
Camshaft bearing	Loose or worn	Slight knock	Replace with new
Inlet-valve seat	Warped or pitted Dirty	Rattle Poor compression Blowback	Use reseat reamer Clean off and grind to seat
Inlet-valve spring	Weak or broken	Blowback in carbureter	Replace with new
Inlet valve	Closes late Opens early	Blowback in carbureter	Time properly
Valve-stem guide	Worn or loose	Rattle or click	Replace with new guide
Cam-follower guide	Loose	Rattle or click	Replace with new guide
Valve-stem clearance	Too much Too little	Click Blowback in carbureter	Set inlet gap 0.010 Set exh. gap 0.010
Push-rod retention stirrups	Nuts loose	Rattle Blowback in carbureter	Tighten nuts
Crank-case gaskets	Leak	Oil leak	Tighten bolts Replace with new
Cylinder or piston	No oil Poor oil	Grinding and sharp knock	Repair oil system Use best oil
Piston	Binding in cylinder Worn oval causing side slap	Grind or dull squeak Dull hammer	Lap off excess metal Replace with new
Oil sump	Insufficient oil Poor oil	Grind and squeak in all bearings	Replenish with best oil
Piston rings	Defective oiling	Squeak, hiss, grind	Replace with new ring Repair oil system
Crankshaft	Defective oiling	Squeak	Clean out oil holes Use best oil Repair oil system
Engine base	Loose on frame	Dull pound	Tighten bolts

In the twelfth article of this series, which will appear in the July issue, rotary engines and V-shaped multi-cylinder aviation motors will be considered.

Aviation News

Steel Airplane Traps for Allied Aviators

At Zeebrugge, the German naval and aerial base on the Belgian coast, the Germans have adopted a new method of catching hostile airmen.

Toward evening, says the "Telegraaf" (Amsterdam) frontier correspondent, the Germans send up twenty captive balloons, without crews and attached to electrified steel cables. The electric barrier is said to constitute a menace to all airmen coming in contact with it.

The Germans, it is added, have also manufactured a new and improved type of airplane. It is fitted with three propellers, one being so arranged it can keep the airplane stationary above a certain point for a few minutes, thus permitting the bomb thrower to aim with greater accuracy.

New Heads of Aircraft Boards

Left—John D. Ryan, "the copper king," who has been appointed director of aircraft production for the Army.

Right—Brig.-Gen. Wm. L. Kenly who will direct the newly created Division of Military Aeronautics. It will be responsible for the training of aviators and will direct the air forces. This work has heretofore been under the direction of the Signal Corps.

4,500 Men to be Drafted for Aviation

Provost Marshal General Crowder has announced that 4,500 draft registrants will be called to equip themselves to assist in the maintenance of the Air Fleet. The call affects Illinois, Minnesota, Iowa and Indiana, and the selected men will be given a thorough training course in woodworking and gas engine operation and repair. Fourteen educational institutions have been selected by the government.

The voluntary induction system will be tried, but where the State fails to produce its quota, local boards will be directed to conscript enough men to fill it. It is specified that the registrant must have had a grammar school education.

The schools and quotas which each State is directed to send follows:—

Minnesota—Three hundred men to Carnegie School of Technology, 500 to University of Cincinnati, 500 to University of Minnesota, 180 to Pennsylvania College, 320 to University of Pittsburgh.

Illinois—One hundred men to University of Chicago, 200 to Lewis Institute, Chicago; 100 to Northwestern University, Evanston, Ill.; 300 to Bradley Polytechnic Institute, Peoria, Ill.

Iowa—One hundred to New York University, 400 to University of Wisconsin, 500 to Rahe Automobile and Tractor School, Kansas City, Mo.; 500 to Sweeney Auto School, Kansas City, Mo.

Indiana—Five hundred to Purdue University, Lafayette, Ind.

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Will Send No More Untrained Aviators to France

E. Percy Noel, of the New York Globe, is authority for the statement that from now on practically no pupils or pilots will be sent to France to begin or complete their training. Already one advance school, which was partially borrowed from the French, has been abandoned by the Americans. Elementary and advanced schools developed from a French nucleus or wholly created in France by the Americans will become aviation reserve depots for trained pilots.

These pilots arriving from home and also squadrons of enlisted men will have equipment and opportunity for practice so as to be tuned up to top pitch flying ability until ordered to the front. Pupils from ground schools and also military pilots have been sent to France in the past because of the lack of facility principally in the matter of airplanes and instructors for their training at home. Until the latest types of the fastest machines could be reproduced in America instruction was impossible.

Seaplanes Destroy U-Boats in Face of Odds

Under a heavy attack from three German submarines and three German destroyers, a British seaplane recently persisted in her efforts against another enemy U-boat, and succeeded in sinking it before being damaged by the fire of the other enemy warships, says a recent press dispatch.

The seaplane was on patrol duty at 8:30 o'clock in the morning when a submarine was sighted on the surface with a man standing forward by the gun. Increasing her speed, the seaplane dropped to an altitude of 600 feet and released a bomb. As she swooped around to repeat the attack, a shell from the U-boat burst in the air fifty feet from the propeller. It was seen that the bomb had made a direct hit, a big rent being visible in the deck of the submarine. Just then, out of the mist ahead appeared three more enemy submarines, followed closely by three destroyers.

All six vessels maintained a hot fire against the seaplane, which succeeded however in dropping a second bomb near the disabled U-boat. It exploded fifteen feet ahead of the bow of the submarine. The whole craft shook and then sank quickly in a pool of oil, bubbles and wreckage. The seaplane, having no more bombs, and as the destroyers were coming nearer, returned to its base.

Seaplanes also have accounted for three other submarines. In one case two large seaplanes attacked a submarine on the surface and with two Germans standing on the conning tower. One plane dropped a bomb to the starboard of the U-boat, while the other placed one squarely in front of the conning tower. The explosion of the second bomb was followed by several explosions within the submarine, which disappeared.

Diving from a height of 4,000 feet to 1,200 feet, another seaplane dropped a depth charge on the spot where a submarine had disappeared. When the water subsided, the shape of the submarine could still be seen below the surface and a second bomb was dropped, "after which the ship disappeared."

An enemy submarine about two hundred feet in length and with two periscopes was sighted by a seaplane on patrol duty. The seaplane descended 3,300 feet to a height of 800 feet and dropped two bombs as the Germans submerged. One of the bombs made a direct hit just behind the conning tower. The submarine turned upside down and sank. Oil and wreckage later came to the surface.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE XIV

By Elmer E. Bucher

Director of Instruction Marconi Institute

EDITOR'S NOTE—This is the fourteenth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

GENERAL CONSIDERATION

(1) We have shown the fundamental radio frequency circuits of the transmitter and receiver and the necessity of establishing resonance between the transmitter and receiver to establish communication.

(2) Because aerials rarely possess identical values of inductance and capacity, the antenna at the receiving station must be provided with a **variable series inductance** and **variable series capacity.*** These permit the receiving aerial to be tuned to wave lengths above and below the fundamental or natural wave length.

(3) An **increase of inductance** at the base of the aerial places it in condition to respond to long wave lengths, and the **insertion of a series capacity** makes it responsive to waves below its natural wave length.

(4) In some cases both series inductance and capacity are employed simultaneously to obtain a greater degree of selectivity, that is, to permit discrimination between interfering stations. The natural decrement of the aerial circuit is thus changed to a favorable value.

(5) The **secondary** circuit of the receiving system contains a **secondary variable inductance coil, a shunt variable condenser,** an **oscillation detector** and a current translator—usually a **head telephone,** the **tuning elements** being the secondary coil and the shunt condenser.

(6) The antenna system of a receiving station comprises:
(1) an aerial tuning inductance popularly known as the "loading coil";
(2) a primary inductance to transfer energy to the secondary circuit;
(3) a short wave series condenser.

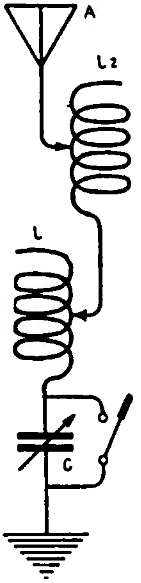


Figure 121.—Showing the correct position of the tuning elements in the antenna system of a receiving station. L-2 is the aerial tuning inductance; L-1, the primary winding of a tuning transformer, and C a short wave variable condenser. The function of L-2 is to tune the antenna system to waves above its natural wave length; of L, to transfer energy to a secondary coil (not shown); of C, to tune the antenna system to waves shorter than the natural wave length of the aerial.

* A shunt variable inductance or shunt variable capacity also may be employed for tuning purposes.

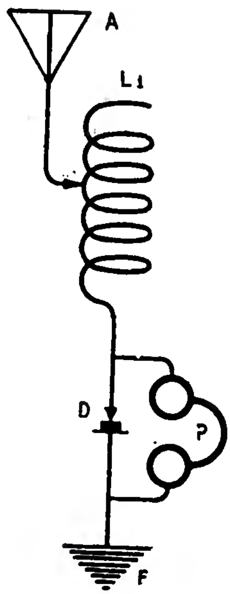


Figure 122

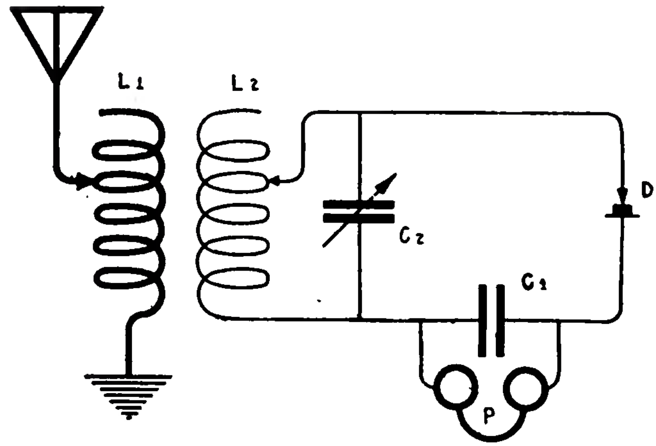


Figure 123

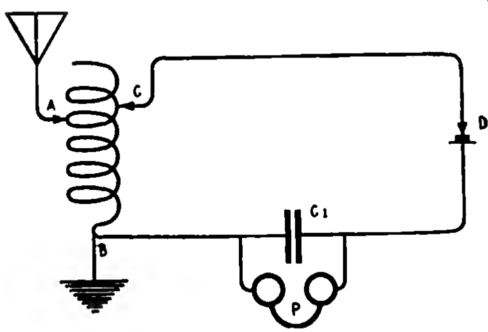


Figure 124

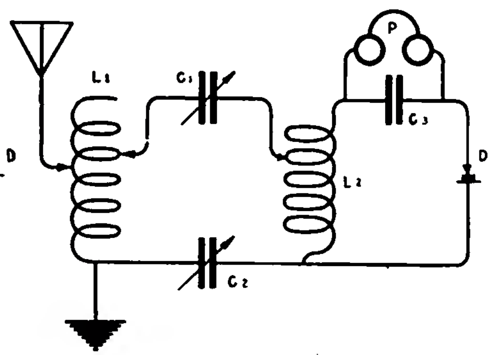


Figure 125

OBJECT OF THE DIAGRAMS

(1) Figure 122. To outline the circuits of a simple wireless receiver.
(2) Figure 123. To show the circuits of an inductively coupled receiver.
(3) Figure 124. To show the circuits of a direct or conductively coupled receiver.
(4) Figure 125. To show the circuits of an electrostatically coupled receiver.

PRINCIPLE

An oscillation detector may be connected directly in series with the antenna system, but better results are generally obtained by placing it in a local oscillation circuit which is coupled inductively, conductively, or electrostatically to the antenna system.

DESCRIPTION OF THE DRAWINGS

In figure 122, crystal rectifier D connected in series with the antenna circuit A, L-1, E, is shunted by the head telephone P. This is known as the plain aerial connection.

In figure 123, the primary winding of the receiving transformer is indicated at L-1, the secondary winding at L-2, the shunt variable condenser at C-2, the crystal rectifier at D, the head telephone at P, and the shunt condenser at C-1. Coils L-1 and L-2 are in variable inductive relation.

In figure 124, a single coil is employed to transfer the incoming oscillations from the antenna circuit to the local detector circuit. The turns A to B include those of the primary circuit. The turns B to C are those of the secondary circuit. The complete circuit comprises the crystal rectifier D, the head telephone P, and the shunt condenser C-1.

In figure 125, the primary winding of the receiving transformer is indicated at L-1, the secondary winding at L-2 in series with which are the condensers C-1 and C-2. The detector circuit comprises the coil L-2, the condenser C-3, the telephone P, and the detector D. L-1 and L-2 are said to be electrostatically coupled through condensers C-1 and C-2.

OPERATION

The apparatus in figure 122 functions as follows: A train of electromagnetic waves radiated by the transmitter induces a radio frequency alternating current in the aerial circuit A, L-1, E. This current will flow freely through the crystal in one direction, but will be opposed in the opposite direction. In one direction, let us say, the current passes from the earth upward through the crystal and then places a charge on the aerial wires, but the return current is opposed; hence the rectified oscillations for each spark of the transmitter accumulate a charge on the antenna wires which at the condenser C-2 through the circuit D, P, C-1 being oscillatory is rectified by D and a charge for each group of oscillations accumulates in the condenser C-1. kind does not possess the tuning qualities of the coupled circuits.

The apparatus shown in figure 123 functions as follows: The radio frequency current flowing through the coil L-1 induces a current of similar frequency in coil L-2, resonance being established by the shunt condenser C-2. Thus the oscillations in the complete receiving system attain their maximum amplitude. The discharge of the condenser C-2 through the circuit D, P, C-1 being oscillatory is rectified by D and a charge for each group of oscillations accumulates in the condenser C-1. C-1 then discharges through the head telephone P in one direction. Resonance may be established between the primary and secondary circuits without the use of the shunt variable condenser C-2, the necessary capacity being found in the distributed capacity between the turns of the secondary coil. A circuit of this kind gives more favorable results with oscillation detectors which depend for their action upon the value of the voltage impressed, than a circuit in which a shunt variable condenser of considerable capacity is employed.

In the apparatus shown in figure 124, the radio frequency current flowing through the turns A to B sets up a magnetic field which cuts through the remaining turns B to C, and a current of similar frequency is impressed across crystal detector D, where it is rectified. A charge accumulates in C-1 over the duration of a group of oscillations and C-1 discharges into the head telephone P.

The apparatus shown in figure 125 is said to operate as follows: Radio frequency current flowing through the coil L-1 is transferred through the coil L-2 by condensers C-1 and C-2, the coupling between coils L-1 and L-2 varying as the capacity of the condensers.

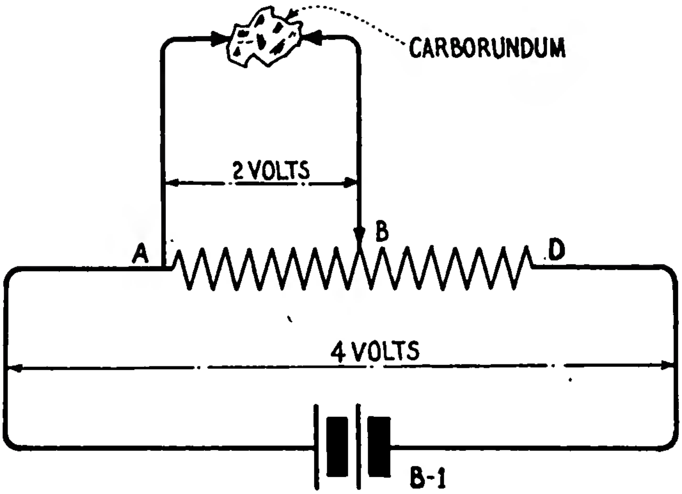


Figure 126

OBJECT OF THE DIAGRAM

To show the use of a potentiometer and battery in connection with crystal rectifiers.

PRINCIPLE

By applying a local current to a crystal rectifier, advantage can be taken of its non-uniform conducting properties to make a sensitive oscillation detector.

DESCRIPTION OF THE APPARATUS

A battery, B-1, of 2 to 4 volts is shunted by a potentiometer A, D, of 300 to 500 ohms resistance. A variable connection, B, can be placed at any point upon the resistance coil A, D. If the potential across A, D, for example, is 4 volts, the potential across the carborundum rectifier may be reduced to any desired lower value as the contact B is moved in the direction of A. Moved in the opposite direction, the potential applied across the carborundum crystal increases to the maximum E. M. F. of the battery. Thus very close regulation of the applied voltage can be obtained.

SPECIAL REMARKS

(1) Potentiometers may be made of German silver wire wound on an insulating base, over which moves a variable contact; or a sliding contact may make connection with a semi-circular graphite strip. Occasionally potentiometers are made of carbon buttons which are connected in series and successively cut in the circuit by a multi-point switch. Some potentiometers are wound in the form of a coil of resistance wire, taps being brought out at intervals to the terminals of a multi-point switch.

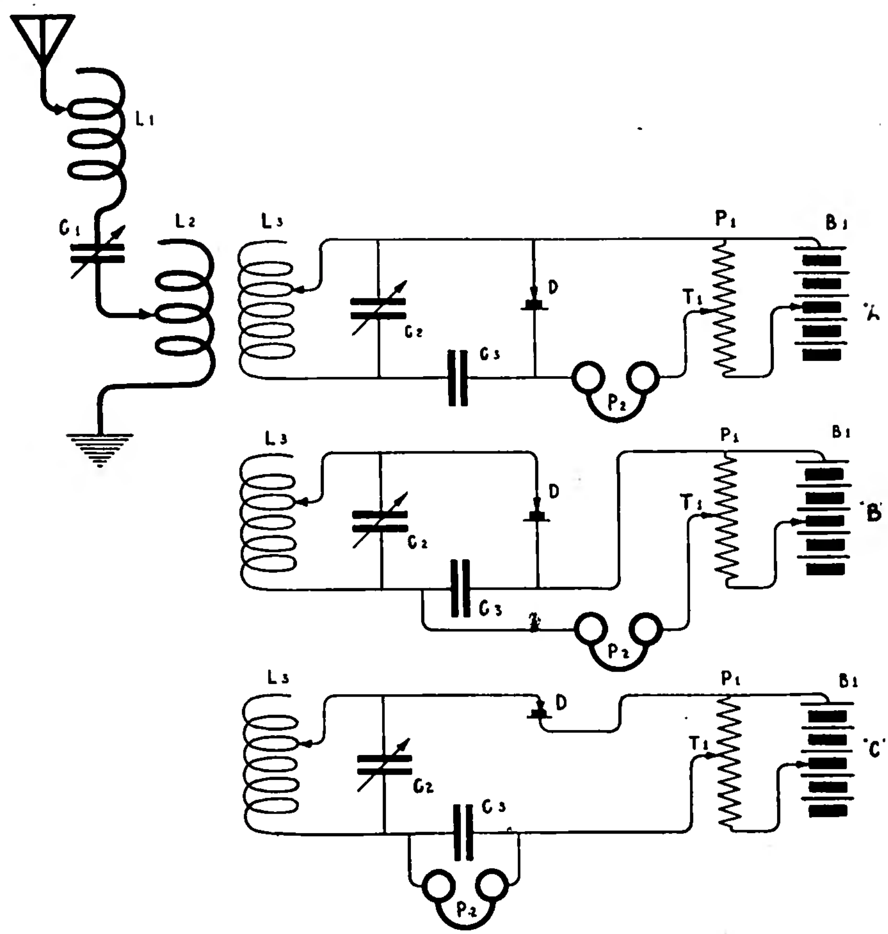


Figure 127, *a, b, c*

OBJECT OF THE DIAGRAM

To show the fundamental circuits of the inductively coupled receiving tuner connected to a carborundum rectifier, and to outline the various modes of connecting the potentiometer and battery to the crystal.

PRINCIPLE

The application of a local E. M. F. to a carborundum crystal permits advantage to be taken of its non-uniform conductivity, making it a more sensitive detector of the passage of radio frequency currents.

DESCRIPTION OF THE DRAWING

In figure 127a the aerial tuning inductance is represented at L-1, the short wave variable condenser at C-1, the primary winding of the receiving transformer at L-2. The secondary winding is indicated at L-3, the shunt variable condenser at C-2, a crystal rectifier at D, and the stopping or blocking condenser at C-3. A potentiometer is indicated at P-1 shunting the battery B-1. The head telephone is shown at P-2 ,having the variable contact T-1 which may be moved back and forth upon the potentiometer.

In figure 127b, the telephones, potentiometer, and battery are connected around the condenser C-3, current from B-1 flowing through P-2 through coil L-3, through the crystal D, to the opposite pole of the battery.

In figure 127c, the potentiometer, crystal, head telephones, and the coil L-3 are connected in series.

OPERATION

The manipulation of the potentiometer for the most sensitive adjustment of the crystal is practically the same in all cases, the sliding contact T-1 being moved back and forth upon P-1 until the loudest signals are obtained. It is necessary that the current from the battery B-1 flow in a definite direction through the crystal D, and if the battery is not provided with a reversing switch, the operator must either turn the crystal D about in its holder or he must reverse the connections of the battery.

SPECIAL REMARKS

(1) The potentiometer P-1 should have at least 400 ohms resistance, as it is shunted to the battery at all times; if of lower value it would exhaust the battery in a short time.

(2) The circuit of figure 127a is the one employed during the period 1906 to 1912 in connection with the carborundum rectifier. The circuit of figure 127b was later adopted by commercial operating companies in the United States. The circuit of figure 127c is fundamentally that employed in tuners designed by the English Marconi Company.

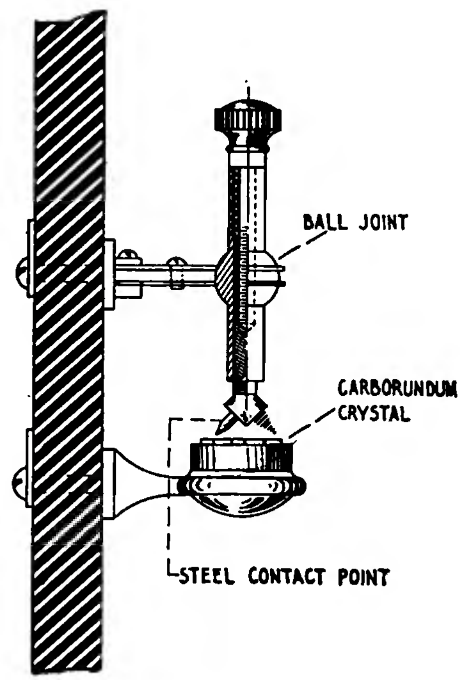


Figure 128.—Showing the construction of the carborundum crystal detector of the American Marconi Company. A number of carborundum crystals are embedded in a retaining cup which extends vertically from the panel of a receiving set. A steel contact point, usually a phonograph needle, is mounted on an adjustment rod which in turn is supported by a ball joint so that the steel contact point can be oriented about the several crystals. A fine wire contact point permits the use of a crystal rectifier, such as cerusite, which requires light contact pressure. In practical adjustment, the operator merely shifts the position of the steel contact point on the crystal simultaneously adjusting the potentiometer until the loudest signals from a given station are obtained.

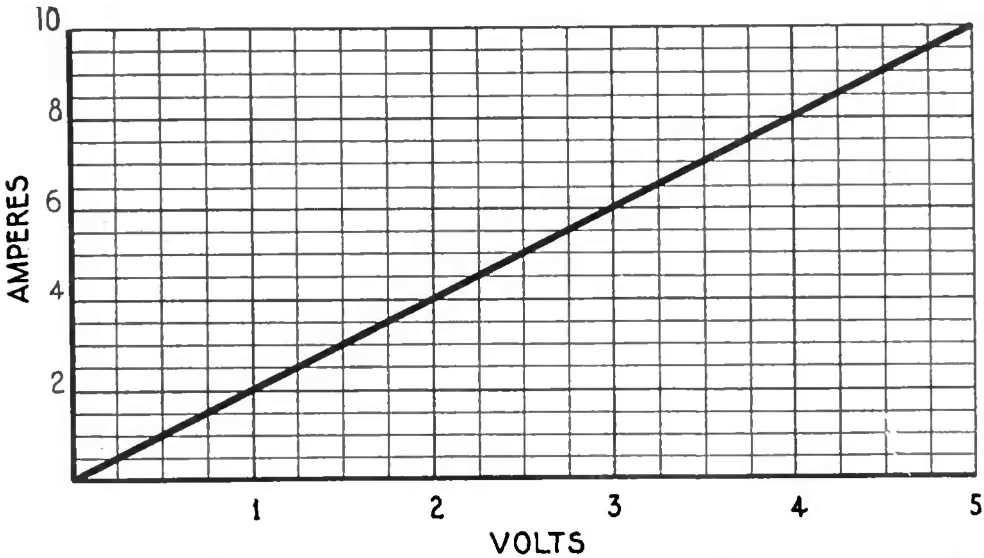


Figure 129.—Showing the current-voltage characteristic of an ordinary resistance. According to Ohm's law, if the E.M. F. of any circuit be increased, the flow of current will be increased in the same ratio provided the resistance of the circuit does not change on account of the rise of temperature. If a direct E. M. F. is applied to a circuit of given resistance and the voltage is progressively increased, the corresponding reading of the ammeter in series with the circuit being noted, the data plotted on cross-section paper will give the straight line of this figure. Thus, one volt corresponds to a current of two amperes, two volts to a current of four amperes, and three volts to a current of six amperes, and so on. Rectifiers such as carborundum, employed for detection of oscillations in radio telegraphy do not obey Ohm's law. In other words, they do not possess a steady or uniform resistance.

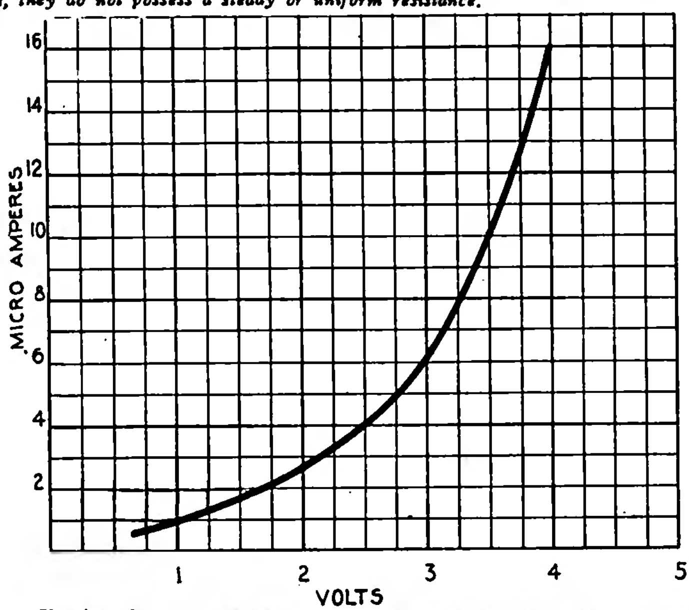


Figure 130.—Showing the current-voltage curve of a carborundum rectifier. It will be seen that an increase of voltage in the lower part of the curve does not result in a uniform increase of current, but after the applied potential reaches a value of three volts, a slight increase in voltage results in a much greater increase of current than is obtained in the first part of the curve. This figure shows the lower bend of the characteristic curve and part of the vertical slope. If the plotting was continued, the upper end of the curve would flatten. If the curve of figure 130 were applied to the circuit of figures 127a, b and c, the operation of the circuits under the influence of an impressed radio frequency current would be as follows. For example, if the E. M. F. of the battery current impressed across the crystal D, is three volts, we note from figure 130 that the corresponding current is six microamperes. Now, let the alternating current of radio frequency (of the incoming signal) have a potential of one volt and let it be superposed upon the battery flowing through the crystal. Then, in one direction, the voltages will add, and the total E. M. F. will be four volts. From the curve, the corresponding current is found to be 16 microamperes. But when the impressed E. M. F. flows in the opposite direction, it opposes that of the local battery, and the resulting E. M. F. is two volts. Reading from the curve, we obtain a current reading of 2.5 microamperes. It will thus be seen, under the influence of the first cycle of the impressed E. M. F., that the current of the local battery circuit varies between 2.5 and 16 microamperes. The sound produced in the head telephone, however, will be proportional to the difference between the initial current (about six microamperes) and the average [illegible] external oscillating voltage is applied.

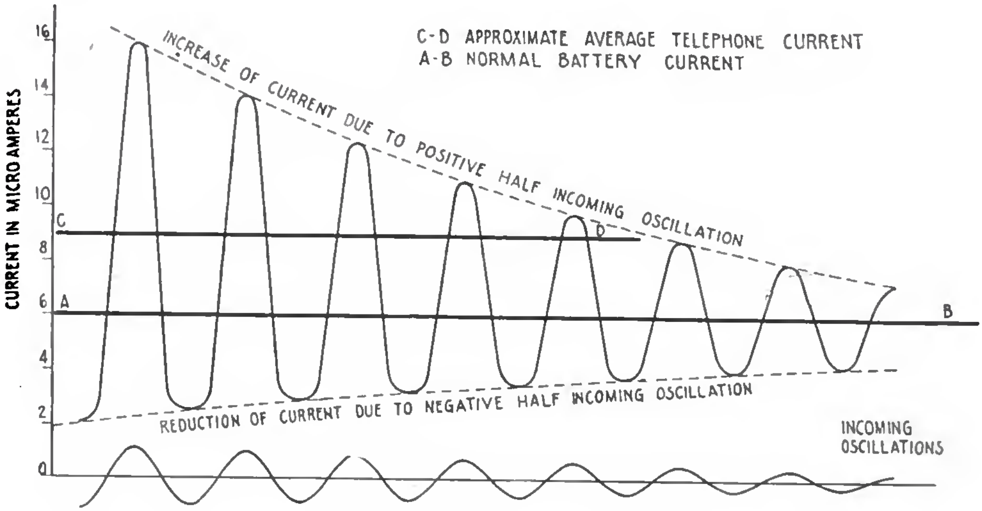


Figure 131.—Curve showing the fluctuations of the local battery current flowing through the carborundum rectifier during the reception of signals. As stated in connection with figure 130, the normal current flowing through the head telephone when no oscillating E. M. F. is applied is six microamperes, the voltage of the battery being three volts. But when an oscillating E. M. F. of one volt is added to that of the local battery, the maximum amplitude of the battery current for the initial cycle of the incoming oscillations is 16 microamperes, and of course, successive maxima will be of lesser amplitude according to the decay of the incoming wave train. The successive reductions of the normal battery current shown below the line A, B, are relatively small because as is clear from figure 130, for all voltages less than three volts the current (in microamperes) flowing through the local circuit is relatively small. The result of this is seen to be a series of a positive maxima of gradually decreasing amplitude which occur at such frequency that the telephone diaphragm cannot respond to them individually, but they produce an average effect upon the receiver, that is, the movement of the telephone diaphragm follows that of a decaying D.C. E.M.F. We may consider the average current in the case of figure 127a to be 9 microamperes and the difference between the normal current 6 microamperes, and the average current 9 amperes or 3.5 microamperes, to be the current which produces audible sound in the receiving telephone. We must keep in mind that this decaying E. M. F. rises to some value and then slowly dies out. The effect of a single group of incoming oscillations upon the telephone receiver is seen to be an increase of current in one direction during the reception of a complete train of oscillations.

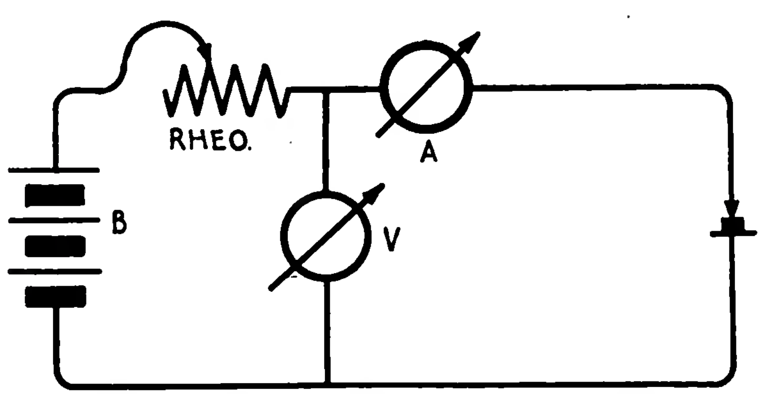
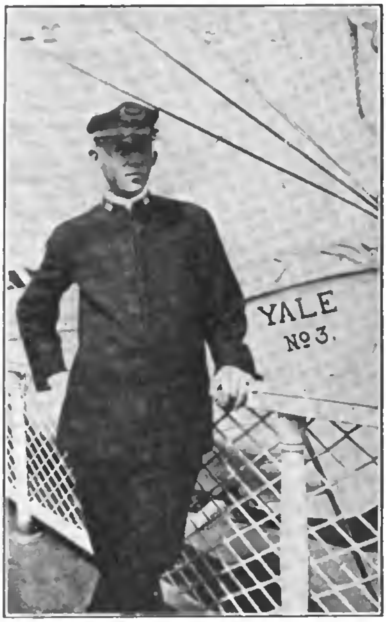


Figure 132.—Showing the apparatus for determining the current voltage characteristic of the carborundum rectifier. The battery B with the series rheostat or a potentiometer is shunted by the volt-meter V. A milliammeter or microammeter A is connected in series with the crystal D. The voltage of B is progressively increased as may be noted by observing the deflections of V. The corresponding current reading is taken from the meter A. The data thus obtained can be plotted on cross section paper in the form of a curve such as is shown in figure 130.

Americans Under Fire at Sea

The Torpedoing of the Actaeon

By G. A. Jensen



Operator G. A. Jensen

OUR third encounter with submarines within a month which ended disastrously for us occurred two days after leaving France for the United States. We left Bordeaux in ballast and when about thirty miles off shore a hydroplane flew overhead and alighted in the water ahead of us. The observer reported a submarine about twenty miles ahead and warned us to give it a wide berth; which we did with pleasure.

Two days later, when about 400 miles from France, we were torpedoed shortly after 7 p. m., without warning of any kind. At the time we thought we were practically out of the real danger zone. We later found we had a submarine on each side.

The torpedo struck in the after part of the ship and sent things flying in all directions in the wireless room.

I was on watch at the time, having relieved the junior operator J. A. Atkins, at 6 p. m.

The ship's dynamo was put out of commission by the concussion. Realizing our main set was useless, we started testing our emergency set to send the distress call, as we were without convoy and alone. The ship started sinking rapidly and all hands were ordered to take to the boats immediately. As the last boat was about to leave I went back on deck and slid down the rope falls, together with the two men who lowered the boat. We were but a short distance from the ship when a submarine appeared out of the briny deep and started toward us; while approaching he Morsed with a light to another submarine some distance away. His wireless masts were stepped and his guns trained on us. About twelve of the crew were on deck with automatics in their hands.

Once within hailing distance they ordered the nearest boat to come alongside. Being true apostles of the safety-first propaganda, the boats started off in different directions bound for nowhere in particular, their object being solely to get as far away from those submarines in as little time as possible.

When torpedoed, we were about 150 miles from the nearest land, in very threatening weather. The following morning found us battling with a gale which continued until after we were picked up. After 36 hours, we sighted land. We thought it was Portugal, but it proved to be Spain. Shortly afterward we sighted a small Spanish coasting steamer which we signaled. We were taken aboard, half frozen and nearly famished.

This vessel landed us in a Spanish port the following day, where we were taken in charge by the American Consul, given clothes and later sent back to the United States on a Spanish passenger ship.

Unfortunately, all of our boats did not fare as well as we did, some of the crew dying from exposure and thirst before being picked up. One boat containing 19 Navy gunners and 5 of our crew has not yet been accounted for.

When the Alamance Went Under

By Harvey R. Butt

Operator Harvey R. Butt

THERE is a law that for every effect there must be a cause. In the case of the Alamance it may have been the second mate who took the skipper's black kitten ashore one night and suggested with the aid of his shoe that kitty disappear up a dark alley. Kitty never returned. Again, it may have been the numerous improvements made in the rooms of the officers (including Sparks'), and that superstition among mariners that such innovations never do the ship any good.

Whatever the cause, the effects may be traced through a chain of minor mishaps to the climax: the torpedoing of the S. S. Alamance on February 5th, 1918, just off the Irish coast.

In port, considerable difficulty was experienced in taking fuel oil aboard, too, and in the middle of the trip the cabin boy nearly died of heart disease while just outside of the war zone our steering gear carried away and we had to heave to for a few hours till the gear was repaired.

We were in a convoy of 25 ships, escorted by a large British cruiser. At the beginning of the trip we were next to the last ship in the second line, but just before we entered the war zone the positions of several ships were changed, and we were then the second ship in the third line.

On the morning of the 5th we sighted the coasts of Scotland and Ireland, and during the day entered the Irish Sea. Having come so far safely and being then inside, everyone felt secure and gave no more thought to Fritz and his highly explosive strafing.

Lest some wiseacre nod his head knowingly at this juncture, I will add that the convoy was still in formation and was zigzaging. We were surrounded by destroyers, light cruisers, and trawlers, also we were highly "cauliflowered" in the latest American fashion. We carried four-inch guns mounted fore and aft, with a gun crew to man them.

I was sitting in the radio cabin, writing, when I heard a tremendous roar and felt the ship give a lurch to port. I lost no time moving out of the room. I remember being thankful that the door had not jammed. I ran to the next door aft, which was the entrance to my room; it would not open so I ran back to the radio cabin and climbed through a cubbyhole which connected with my room. It didn't take long for me to get into sweaters and coats and get on deck again and up to the bridge. Finding no one there I returned to the main deck, just in time to see one of the boats smashed up, spilling several men into the water. Going up to the lower bridge I found the captain; he told me that there was no need of getting out an S O S. Both of the starboard boats had been smashed by the seas but the two on the port side were intact, although the torpedo hit almost directly under one of them. I hopped into one of these lifeboats and helped to pull away from the ship. We started for a light cruiser which had stopped for us, but on sighting two men in the water a little distance from us we turned and pulled over, but were beaten to them by a small boat sent out from the cruiser. A trawler came alongside then and we climbed aboard, setting the lifeboat adrift. The two men picked up in the water were also put aboard the trawler and proved to be our second mate and a seaman.

While they were changing their clothes I went out on deck and watched the good ship sinking, slowly at first and then faster and faster, till the stern was completely under. She stood on end then for a minute, and dropped out of sight.

When the men had changed their clothes for dry ones given them by the crew of the trawler, we were transferred to the cruiser. There we found the rest of the officers and crew. The officers, including myself, were given the use of the officers' wardroom. A supper of canned willie and hardtack with tea was served, sugar and butter being included. During the night hot whiskies were served regularly to those who wanted them. Next morning a breakfast of fried canned willie and ham, hardtack, butter and sugar was served. Just before dinner we ran alongside the landing stage of Liverpool and were landed. The ship's company agent put us up at various hotels after the alien officers had gone through their usual red tape, and for nine days we lived on fish and chips, without sugar and only a little butter for the war bread.

It was a very happy party that stepped ashore in New York.

On the Schuylkill, Hun Victim

By D. C. Smith

Operator D. C. Smith

THE American steamer Schuylkill, owned by the Greek Line, left New York bound for Piræus, Greece, on the 13th of October. Speaking for myself and a few others of the crew, we would have been better satisfied if the good ship had delayed her departure until the morning of the 14th, but what can one expect with a one-eyed black cat aboard!

It was agreed after sailing that the cat should live; perhaps he might counteract the ill-omen of our sailing on the 13th. Now I believe that the cat must have been born on the 13th of the month. Anyhow, we were 21 days going to Gibraltar, where an English gun and two English gunners were put aboard and we left for Oran on the north coast of Africa in the province of Algeria—on the 13th again!

Mildly surprised that we arrived at Oran O.K., I decided to see the town. I saw about twenty dollars worth of the place, and then decided that Africa wasn't so uncivilized. One can't buy gold bricks in Oran, but one can buy 5 franc notes for five dollars, without half trying.

We left Oran without convoy on the evening of the 20th, intending to be in Algiers the next day. I stayed on watch until 5:30 a. m. for two reasons, namely; to pick up submarine warnings and also to figure out a new process by which I could extract money from the skipper to see Algiers when we arrived there.

I came off watch at 5:30 and after hanging all my clothes on a hook in back of the door I turned in.....Well the clothes that were on the hook, and a few others, are on the bottom of the Mediterranean. My B. V. D.s I still have.

The torpedo hit us amidships, right abreast the radio room, just an hour and 20 minutes after I turned in. The explosion must have occurred at least 15 feet under the water as the greater part of damage was done to the hull, and the in-

(c) Press Ill. Svce.

An airplane bombing attack successfully executed is shown in this picture taken above the storehouses and railway sidings at Beyrout harbor. A direct hit by the bomb is revealed by the puff of smoke rising from the pier in the center of the illustration and the commencement of a fire from bombing at a point to the right is disclosed by the larger volume of smoke terior of the ship was practically intact except for a few of the partitions that were blown down. The table that the wireless instruments were on was blown down and the instruments were scattered all over the floor.

I didn't waste any time in seeing what damage was done but beat it over to where the companionway led to the deck. It had been blown away.

I found a piece of wreckage that I could stand on and then pulled myself up on deck. The ship had started to list immediately after the explosion and as I reached the deck she had begun to straighten up, but was settling fast. Two life-boats had been blown away and the one I was assigned to tipped over as it was being lowered. The usual amount of nervousness prevailed, and I was doing my share and a little more of some one else's.

After everyone was clear of the ship two of the fellows righted the lifeboat and pulled some of us in. A French destroyer was on the horizon and the submarine, after trying to ram the life-boat which later picked us up, passed about three feet from me as I was hanging on to a piece of lumber. The Hun craft started to come up; then apparently seeing the destroyer she quickly submerged and disappeared among the floating wreckage.

The French destroyer, and also an American patrol boat, came circling in and picked up the crew. From the French boat we were landed in a small town called Tenez which we had passed earlier in the morning. We were treated very kindly there, and it was evident that the French people, though they had little themselves, would gladly give what they did have to anyone that needed it more than they.

We were sent by the French Government over the mountains in big auto trucks to a little town called Orleansville, from there taking the train to Algiers where we saw the American consul and were supplied with what clothes could be bought for us. Then is the time to wish for an American tailor!

We were in Algiers three days and left on a French troopship for Marseilles. We arrived in Marseilles at night and left the next night for Bordeaux to take ship for New York.

When we arrived in New York on the 14th of December there was no one any more convinced than I that Sherman was right. It's a great life if you don't weaken.

Special Feature for July

"The Progress of Radio Telephony"

By E. E. BUCHER

In the July issue of THE WIRELESS AGE a special article entitled "The Progress of Radio Telephony," will describe some important developments in radio heretofore unpublished. Combination wireless telegraph and telephone transmitters in which telegraphic and telephonic messages are radiated from the same antenna simultaneously, will be discussed, together with the latest developments in duplex systems. The disclosure of the actual circuits in which vacuum tubes are employed foı the generation of radio frequency currents at high power, and also for their control at speech frequency, make this article a specially valuable contribution to this department of radio research.

A Digest of Electrical Progress

The Growing Need for Hydro-Electric Power—The Testing of Direct Current Meters—Computing the Weights of Conductors—The Uni-Polar Generator—How to Remove Moisture from Transil Oil—An Electrostatic Voltmeter.

The Growing Need for Hydro-Electric Power

ACCORDING to a statement issued by Professor D. M. Folsom, Pacific Coast Petroleum Administrator for Mark L. Requa, a United States Oil Administrator, the electric power requirements of the Pacific Coast increase by 10 to 15 per cent. per annum.

The usual rate of oil consumption in California is almost 110,000,000 barrels per year, which does not meet the present demand. At present 20 per cent. of the total power utilized on the Pacific Coast is developed from hydro-electric plants and 70 per cent. from fuel oil and natural gas. Realizing the seriousness of the matter, the Administration is urging the installation of water-power plants throughout the Coast. In a recent statement, the administrator says: "With the output of oil barely maintained or declining each year this increase must be entirely met through the development of more hydro-electric plants on the Pacific Coast. A conservative estimate of further requirements shows that the installed generating capacity of the plants now on the Pacific Coast should be doubled in five years and tripled in eight years to meet the local requirements for purposes of power, light and heat."

The Testing of Direct Current Meters

IN a recent issue of the Electrical World, J. M. M'Clurg describes a simple arrangement for testing both large and small direct-current meters—that can be adapted to any size load. The board has two distinct loads, one being on 110-volt direct current with resistance for a load up to 32½ amperes. The other load is a storage battery and depends upon the size of the battery used. The magnitude of the load is controlled by a double-pole, double-throw knife switch which makes it possible to leave the triple-pole switch in circuit during the test and changing over from full load to light load by using the double-pole, double-throw switch. This is shown in the diagram, figure 1.

This arrangement saves time, the tester setting the load he desires by the small single-pole, single-throw switches for light load and a carbon rheostat in the battery circuit for full load, thereby leaving but one switch to operate during the test.

A carbon rheostat is provided, the carbons being separated into sections by brass plates. This permits the operator to cut out sections of the plates if the resistance proves too great, the brass plates being connected to the

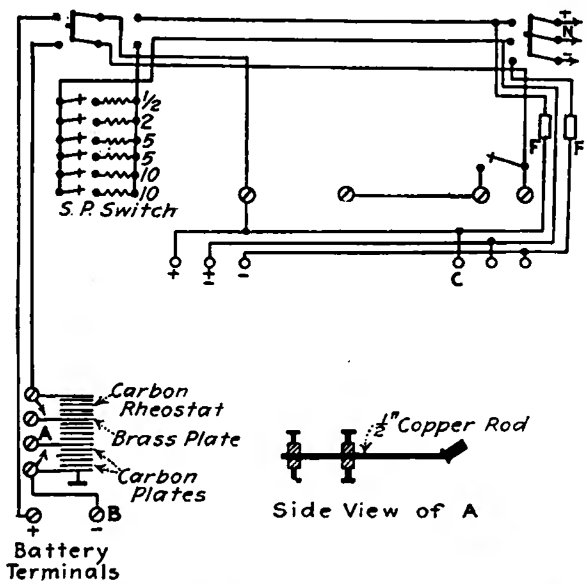


Figure 1—Arrangement for testing direct current meters

binding posts marked A. A copper rod slides through the binding posts so as to short-circuit part or all of the carbon rheostat, as the test requires. This is a convenient carbon rheostat that can be used for light or heavy loads. Of course, by increasing the sizes of the load, terminals, circuits, etc., the board can be built for any desired capacity.

Computing the Weights of Conductors

BY employing the formula W = K × cir. mil × L, the weight of a round conductor of any metal may be readily figured if the size and length of the wire and the weight per circular mil foot of the metal composing it are known. So we are told by Harry H. Barth in a recent issue of the Electrical Review.

In the foregoing formula W = the weight in pounds of the wire;
cir. mil = the area of the conductor in circular mils;
L = the length of the wire in feet;
K = the weight in pounds per circular mil foot of the metal.

Among the commoner metals, the following are the weights in pounds of one circular mil foot of each: Copper, 0.000,003,03; aluminum, 0.000,000,916; galvanized iron, 0.000,002,64; galvanized crucible steel, 0.000,002,64.

The Uni-Polar Generator

SINCE first brought out by Faraday, many direct current generators of the uni-polar type have been constructed, but the manner in which certain types function has been a point much discussed. In the December number of the Physical Review Professor George B. Pegram describes the action of uni-polar induction in terms of the electron theory.

A typical type of uni-polar generator which has occasioned much discussion consists of a cylindrical, permanent, bar magnet rotated by power about its axis and having two stationary brushes applied to its rotating surface. One of these brushes is placed, say, at or near the middle of the magnet. The other is applied near to one end of the magnet. Current flows from these two brushes through an external circuit in the usual manner, the direction being from the middle brush through the magnet and out from the end brush. The particular point of argument is whether the E. M. F. is generated in the substance of the rotating magnet, in spite of the fact that if the magnet carries its magnetic field around with it, this field, apparently, cannot cut the moving substance. Another theory is that the E. M. F. is generated in the stationary part of the circuit external to the brushes.

Professor Pegram takes the stand that the current is generated in the substance of the moving magnet, and he explains his theory in terms of electrons. He concludes, in general, that the E. M. F. generated in an element of a conducting circuit may be produced either by real rate of change in the potential at that point or by the transverse motion of the element with respect to a magnetic field. In event of the latter, the field need not be stationary. The field may or may not be in motion. If the conducting element moves an E. M. F. will be generated therein by the field. As a consequence, a bar magnet generates electromotive force in its own substance when it rotates. Whether the field rotates with the magnet or not is not essential, the only important fact being that the elements of the conductor are moving and are also permeated by a transverse magnetic field.

The author describes experiments repeating the conclusions of Barnett and Kennard regarding uni-polar induction, namely, that the seat of electromotive force is in a moving conductor and is entirely independent of the rotation of the magnetic field. According to the Maxwell field equation in the Lorentz form, no force is exerted on a stationary electron. Therefore there is no E. M. F. induced in stationary conductors in the vicinity of a steadily spinning solenoid carrying a constant current. But when the electron moves there is an E. M. F. on electrons in moving conductors which may be easily seen to be quantitatively just what would be computed on the basis of the calculation of the "rate of cutting of magnetic lines," assuming that the lines of the magnetic field would remain stationary with the conductors rotating.

How to Remove Moisture from Transil Oil

THE best known method of removing moisture from oil is that of using a filter such as the larger electrical manufacturers market specially for the purpose. But these are not always available, and some other method must be improvised.

In a current issue of the Electrical Review Mr. M. S. Montgomery describes a temporary scheme whereby all moisture is removed through a bed of calcium chloride. The particular transformer in which the oil was filtered was of 2,000 kw. capacity and constructed for high voltage, hence it was imperative that the oil should be free of all moisture. The writer goes on to remark that while many ideas suggested themselves, such as heating the oil at atmospheric pressure, or better still in a vacuum, it was decided that it would be safer and quicker to absorb the moisture instead of attempting to drive it off as this latter method is often difficult to perform whilst there is always the possibility of overheating the oil and thereby damaging it.

Just how the process is carried on is shown in the diagram of figure 2.

The oil was passed through a bed of calcium chloride which picked up the moisture and had no deleterious effects upon the oil. The oil was passed through two separated beds of calcium chloride and then through two filters, each of which was made up of two double thicknesses of cheese cloth that had been previously dried by heating. Each chloride bed was made up by

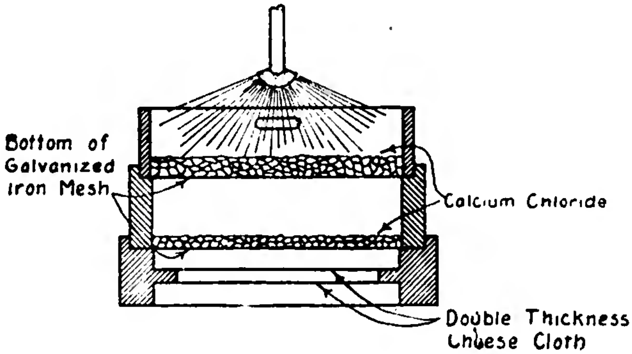


Figure 2—Arrangement of calcium chloride trays and cheese cloth filter for removal of moisture from oil with minimum spillage

fastening a fine mesh to a wooden frame, the one fitting into the other as shown. Beneath, to prevent pieces of chloride being carried over with the treated oil, four pieces of cheese cloth were fastened in a separate frame. This system permitted the oil to be treated as fast as it could be poured out of the oil drum.

To determine definitely that the moisture had been removed, calcium carbide was used to detect its presence after each drum had received the oil. Moisture or water tends to sink to the bottom of any container holding oil, although after agitation a considerable amount of moisture may be held in suspension. Numerous samples were taken in a glass beaker. Into this was dropped a few small lumps of carbide. With the untreated oil a column of bubbles invariably arose from the lumps, indicating chemical action due to the effect of the water on the carbide. With properly treated oil all evidences of bubbles were absent.

An Electrostatic Voltmeter

AN interesting portable instrument for measuring very high voltages such as are used in electrostatic fume and dust precipitation has been described in the Electrical World. The instrument is a modified form of the Kelvin guard-ring galvanometer described in the Electrical World of May 13, 1916. A sketch of the meter is shown in figure 3. The disk D forms one element of a balance beam. The insulating support for the upper plate is removable at the base, and the whole packs readily in a flat box and is easily put together for use.

The instrument is put into operation as follows: Screw S is adjusted so that the upper surface of the disk D is flush with the upper surface of the guard ring G—that is, so that the pointer of the balance registers zero while a 500-milligram weight rests at W. This weight is then removed, whereupon the disk D falls slightly,—that is, until the beam makes contact at T. The plate P is then connected to the high voltage line, while it is some distance from the guard-ring G; it is then lowered by means of a knurled head and ratchet, which unwinds a silk string until the disk D is attracted so again be just flush with the guard-ring G—that is, so that the pointer beam indicates zero. The distance between the plates is then read f scale by the indicator I, which may be marked to read in volts directly

Mr. E. R. Wolcott gives the following equation for design and calibration:

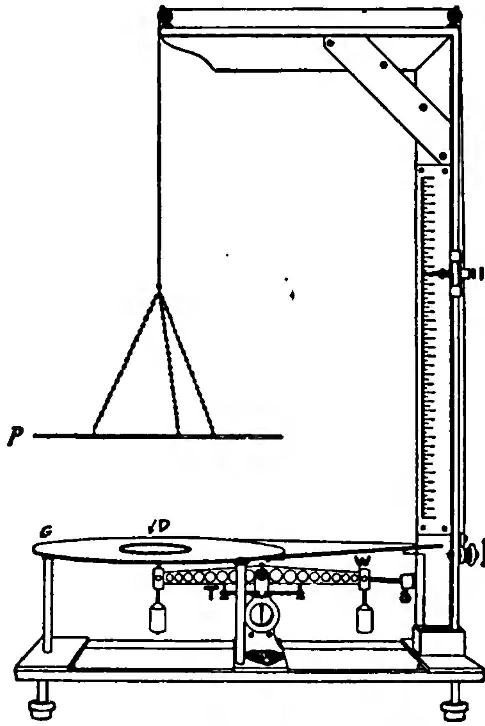


Figure 3—Sketch of electrostatic volt-meter

Since the electrostatic attraction is measured by comparison with the attraction of gravity, if the mass of the weight at *W* and the area of the disk *D* are known, the relation between the voltage *e* and the distance *d* between the plate *P* and guard ring *G* can be expressed as follows:

$$e = 300\, d \sqrt{\frac{8\pi m g}{\pi r^2}},$$ where

e = volts in electromagnetic units;
d = the distance between the plate *P* and guard-ring *G* in cm.;
m = the mass of weight added at *W* in grams;
g = the acceleration of gravity = 980.6;
r = the radius of the disk *D* in cm.;
300 = the constant of transformation from electrostatic to electromagnetic units.

If $m = 500$ milligrams, and $r = 1.5$ in. $= 3.8$ cm., then when $d = 1$ cm.,

$$e = 300 \sqrt{\frac{8 \times 0.5 \times 980.6}{14.5}} = 4935 \text{ volts per cm.}$$

The diameter of the plate *P* and the guard-ring *G* should be larger than the maximum distance to which they are separated.

The diameter of plate *P* in figure 3 was 10 inches. The instrument was used to measure 100,000 volts. Accordingly, the spacing between the plate P and the guard-ring G was about 20 centimeters.

The accuracy of the instrument depends upon that of the beam, which, the writer remarks, is readily constructed so as to permit of readings within 1 per cent.

(c) Int. Film Svce.

So accustomed have Americans become to the detailed reports of fire spotting from airplanes and artillery control by wireless, the direction of bombardments from the ground is almost lost sight of. In this picture a British signalman is shown in summer garb directing his battery from a dugout

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

Tikker for the Reception of Undamped Oscillations

This is the plan and description of a mechanical tikker which I recently constructed. I took as a working basis, an armature of a small 60-cycle Westinghouse series motor. The experimenter who can obtain a similar motor and desires to follow out my construction should proceed as follows:

First, remove the armature windings and magnetic core from the shaft, taking care not to disturb the clamping rings which hold the commutator together.

Next, remove the bearings from the motor, remount them, and re-align the shaft in the bearings. Take a very fine, light piece of watch spring, bend one end into a V shape so that it will rest on the commutator as a brush, and fasten the other end under a binding post. The tip of the brush should be sharp so that it will not bridge two sections of the commutator. With a small soldering iron, solder together the sections of the rim D (figure 1) and then solder a wire in one of the joints. The other end of the wire is soldered to the long clamping ring H, which, in turn, serves as a drive wheel. A wire extends from one of the bearing supports (which, by the way, should be of metal) to another binding post. The instrument can now be considered complete.

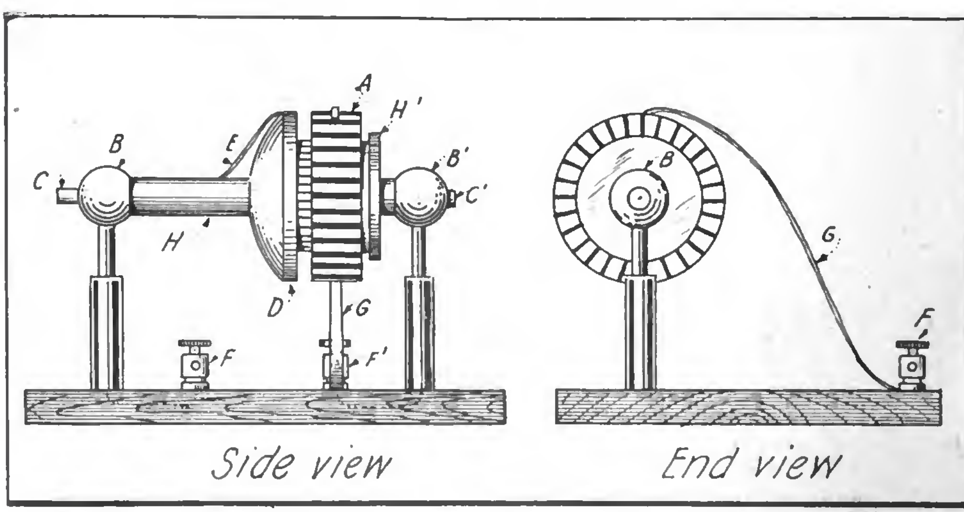


Figure 1 *First prize article* *Figure 2*

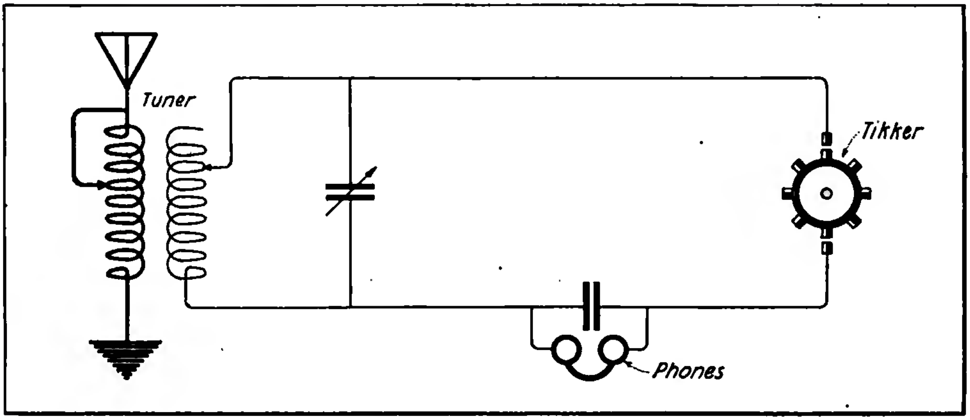


Figure 3—First prize article

The tikker should be driven by motor with a speed control. There may be from 1,000 to 1,500 breaks per second. The most effective way of connecting the tikker is shown in figure 3. If the circuit is tuned to a wave of say 6,000 meters and the signals are not heard, the experimenter should increase or decrease the speed of the tikker whereupon the signals will be received providing the transmitting station is sending. If the tikker revolves too rapidly, the pitch of the note will be above audibility, but the proper speed regulation can soon be found. I used this device before the war and it proved very efficient. The complete details of construction are given in figures 1 and 2, figure 1 showing the mounting of the commutator, and figure 2, the position of the brush.

B. L. Smith, *Concord, Mass.*

SECOND PRIZE, FIVE DOLLARS

Receiving Set Applicable to the Reception of Damped or Undamped Waves

I have noticed many odd looking receiving sets in past issues of The Wireless Age, and I take the liberty of submitting sketches of a long wave tuner which I constructed some time ago for the reception of damped or un-

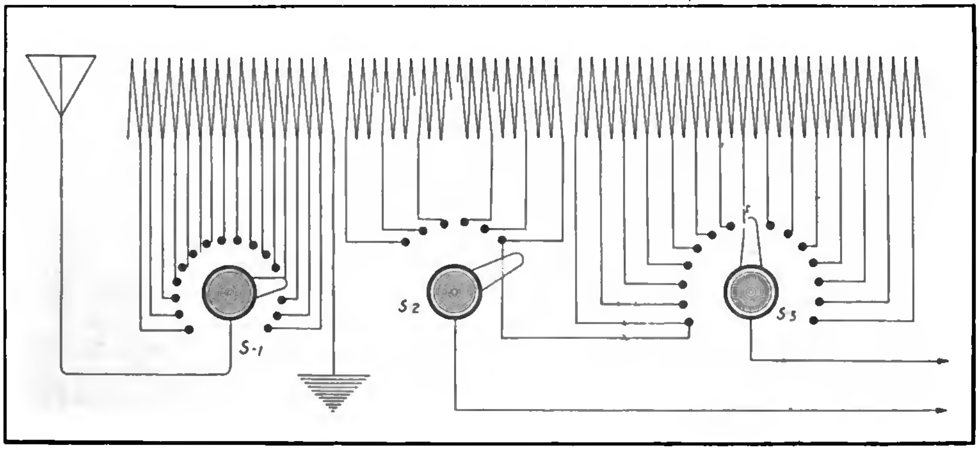


Figure 1—Second prize article

damped waves, with the hope that it will prove of interest.

Figure 2 shows the external appearance of the cabinet; figure 1, the tuner, and figure 3, the circuit. In figure 2, "A" is the aerial post, and "G" the ground. S-1 is a switch for tuning the primary, while S-2 and S-3 are for tuning the secondary. C-1 is a variable condenser across the 'phones. The other connections are plainly shown. No dimensions are given as to constructional details, except for the coupler, which is somewhat out of the ordinary. Details of construction accompany the drawing and no remarks are necessary, except that attention might be drawn to S-2 (the coupling switch). As is seen, the coupling is mechanically fixed, but the switch S-2 makes possible a coupling, mechanically speaking, of from ⅛-inch to 6 inches or more, which is said to be highly desirable for close tuning on the long wave arc signals.

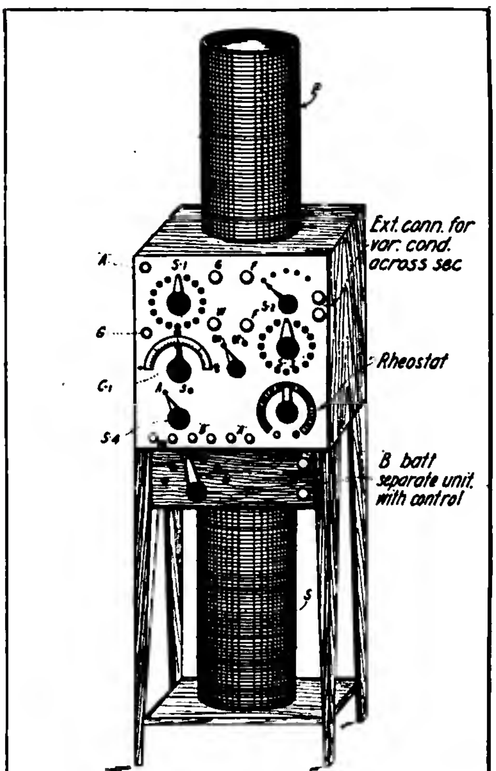


Figure 2—Second prize article

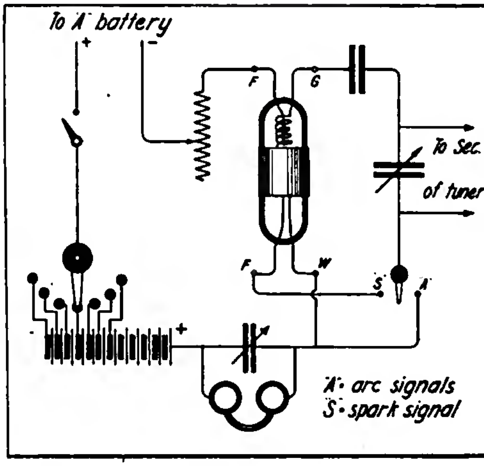


Figure 3—Second prize article

As will be noted in figure 2, there are two binding posts for the external connection of a variable condenser across the secondary. This scheme was resorted to so as to permit the use of this variable in other circuits.

I have not shown a variometer which is supposed to be used in the aerial circuit for close tuning—in other words, to permit regulation of the inductance between the primary taps. The variometer has a rotor 7 inches in diameter and is constructed in the usual manner.

W. T. GRAVELY, *Danville, Va.*

THIRD PRIZE, THREE DOLLARS

An Oscillation Circuit for the Reception of Damped and Undamped Waves

I wish to submit to the "Experimental Section" of your magazine the following description of a receiving apparatus for the reception of damped and undamped waves, which I have devised in anticipation of the grand post bellum opening. The cabinet may be of interest to those amateurs who have a few moments' spare time to experiment in preparation for this great event.

Figure 1 shows the general external appearance of the apparatus. The construction follows:

The panel should be made of bass wood, light and substantial. It should be 18 inches long, 14 inches wide and

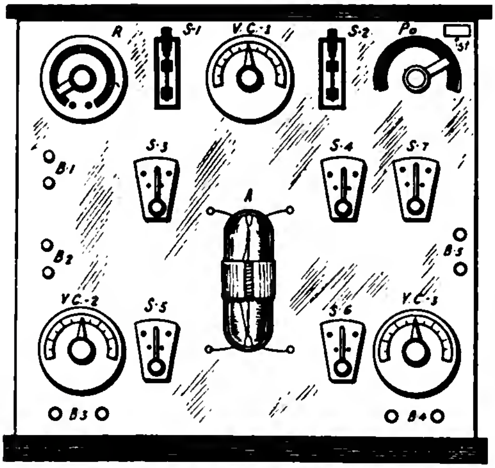


Figure 1—Third prize article

3½ inches deep. It can be richly grained and polished. The thickness of the board should be about 7/16 inches. Three holes 3½ inches in diameter should be cut in the panel cover to admit the variable condensers. All wiring, of course, must be done on the back of the panel cover.

As shown in figures 1 and 2 the instruments of the complete receiver, with the exception of loose coupler, 'phones, and coil (mounted on the outside of the cabinet) are contained inside the cabinet.

The lettering on the diagrams is explained as follows:

R is a rheostat for regulating the filament battery A, which should be 6 volts, 40 ampere hours capacity.

S-1, S-2 is a Trumbell porcelain base, single pole, double throw switch, which is rarely used except to throw the system out of commission in event that meddlers prove too attentive.

Po. is a potentiometer to regulate the E. M. F. of battery B—the high voltage battery of from 45 to 55 volts.

S-3, S-4, S-5, S-6, are two-point switches mounted on hard rubber bases. These permit the apparatus to be used for either spark or arc reception. For spark signals they are moved to the right and for arc signals to the left.

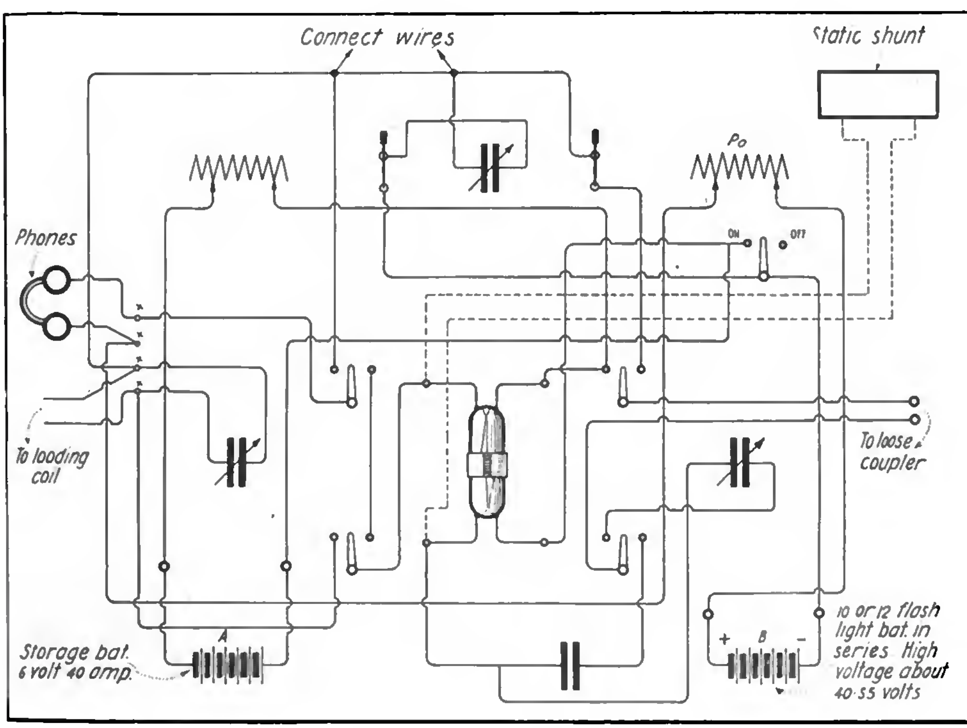


Figure 2—Third prize article

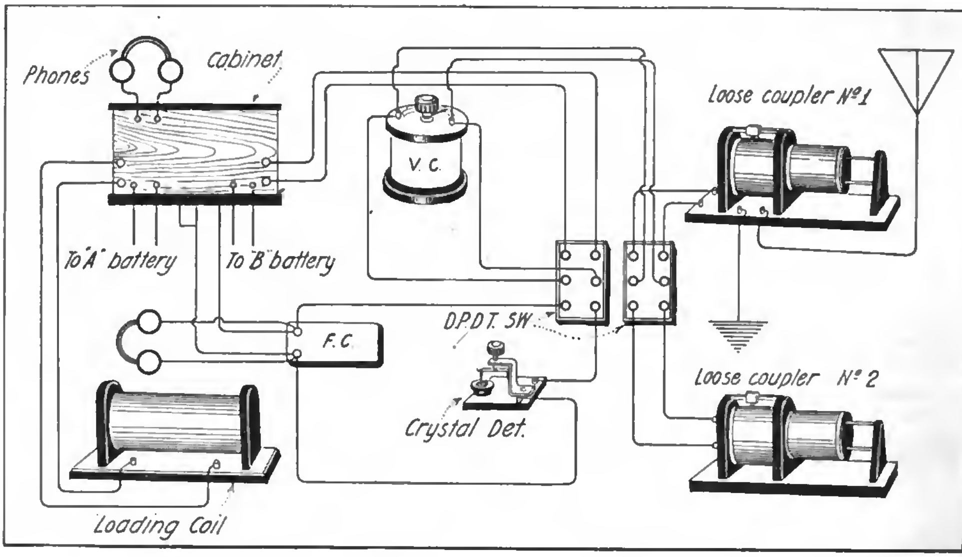


Figure 3—Third prize article

VC-1, 2, 3, are variable condensers of .001 microfarad capacity each. Their use can be easily understood by a careful study of figure 2.

B-1, B-2, B-3, B-4, B-5, respectively, are binding posts for 'phones, loading coil, battery A, and loose coupler.

A is an audiotron for the reception of damped and undamped waves. St. is a static shunt to prevent the accumulation of high potential on the grid or plate condensers. The static shunt is indicated by diagonal lines. Its resistance can thus be either increased or decreased.

Switch S-7 throws the entire system into action, i.e., it lights the audiotron from battery A. When S-7 is thrown to the right the set is out of commission. FC is a fixed condenser.

This set, before the War, gave perfect satisfaction. With it I have received messages over distances up to 3,000 miles.

Experimenters who have the opportunity to construct the equipment described, I feel sure will be pleased with the results they obtain.

I also submit a complete diagram, figure 3, for switching from the valve to a crystal detector condenser. FC is filled with pure castor oil thereby increasing the capacity five times.

Albert J. C. Vian, *Minot, N. D.*

July Prize Articles

"Howler" Code Practice Apparatus

Describing a novel apparatus for the production of audio frequency currents.

Super-Sensitive Receiving Set

Detailed instructions are given for its construction and operation.

A Telephone Cabinet

An interesting cabinet which any amateur can make.

(c) Press Ill. Svce.

The lone sentinel amid the snow-capped mountains on the Italian front is here shown maintaining the vital telephonic communication upon which all major operations are based

The Monthly Service Bulletin of the

NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America
J. ANDREW WHITE, Acting President GUGLIELMO MARCONI, President ALONZO FOGAL, JR., Secretary
NATIONAL ADVISORY BOARD OF VICE-PRESIDENTS

Headquarters, 25 Elm St., New York

Dreamin' O' Seventeen

By Fred W. Jameson

WHERE is the radio enthusiast whose heart doesn't pine for the glorious winter nights prior to April 10th, 1917? The amateur stations have been closed just long enough to make one homesick for the glowing audion, the glistening switch points, and the sweet odor of orange shellac which gave a professional finish to our home-made apparatus. The WIRELESS AGE has sensed this spirit of longing that fills the hearts of all true radio experimenters and invites accounts of experiences prior to the closing of all stations. Nothing else that could be published will do more to keep alive the love of the regal sport that was once within the grasp of any who wished it.

Every radio enthusiast hearkens back to some particular night when the voices in the ether seemed unusually distinct and their messages exceptionally entertaining. I recall one of those nights, and while my log records no unusual long distance captures, it recites events that always will bring a pleasing thrill. It was not a "freak" night, but just one of those snappy winter nights when old man QRN was off the job and QRM was unusually decent.

* * *

NAA had tapped off ten o'clock and the signals were very distinct and loud. A slight change of coupling and switches, and here was Key West ripping out an alarming lot of news about loose bell buoys and dangerous derelicts. A drop back to 200 meters and hundreds of amateurs in all parts of the country could be heard. At 300 a medley of piping notes from ships down in the gulf chimed musically. Some night for radio! I change the simple hookup to a regenerative one, using two variometers as described in "How to Conduct a Radio Club" and the effect was marvelous. A Standard Oil tanker, reporting her position three hundred miles from Tampico, roars in so shrill and loud that I lay off the phones and easily read the signals while sitting in an adjacent room. St. Augustine, Florida, (NAP) hailing a ship, and San Juan, Porto Rico (NAU) come in loud and clear.

Then comes a deafening bombardment from a Ford spark coil in the north part of town. Nothing to do but shut off the audion and wait until the "ham" gets tired. A high wind is blowing and snow sifts against the window panes in fitful furious gusts. The aerial high overhead can be heard whistling shrilly as the wind tears through it; the taut aerial ropes slap noisily against the steel masts.

The air is full of news when once again the audion is switched on. A station out at Victor, Colorado, is complaining of the severe wind in the mountains; —"am afraid my aerial will go any min." he wails. A slight change of switches and coupling and here is Colon, Panama, finishing the night's business with a brief chat about the excessive heat!

What king in his gilded palace can boast a sport more regal than that which I enjoy in my humble den, with the thermometer at two below outside and the wind howling frantically at my aerial high over the fertile hills of eastern Kansas! The centre of the United States and the hub of three thousand miles of gossip by land and sea! What Pandora's box can compare with this magic box of mine that lets me hear the traveler at sea—still two days from port—ordering a room with bath reserved for him in the best hotel in Galveston?

Where is the magic lamp, rub it as you may, that will bring to your ears the booming note of the sinister drab British battleship lying seventeen miles off Sandy Hook, solemnly warning mariners to beware of enemy submarines and "display no unnecessary lights"! The magic carpet could never carry me to more inspiring scenes than those this simple contraption of wood and wire brings close to hand. Here is the weird note of VPP at Nassau, Bahama Islands, advising a Canadian station regarding a shipment of tortoise shell. NAA opens up again with a press report full of war news; Key West is shrilly feeding seagoing folks with the latest news from the blood-stained fields of France and Belgium. War, war, nothing but war! BZQ booms again with a glorious recital of British and French war gains. Down in turbulent Mexico one of the (X) stations,—what an awful call to decipher—opens up in a shrill 500-cycle falsetto and talks Spanish to the Mexican who sits sweltering in his room at Campeachy. Presently his answering note is heard. WHK at New Orleans, always a busy station, is unusually busy tonight and ships on the gulf are whining through the ether in a mad medley of skeeter voices. What a lot of interesting gossip they convey to a landsman in a snowbound town thousands of miles from salt water!

But ships are so common to the operator who has a good outfit! I try for bigger game. Ah, here is WHB (New York Herald) sending press,—interesting, too. And WRU (Port Arthur,

WHERE TO BUY

Texas), another busy gulf station, is impatiently ordering an interfering Norwegian to stand by and keep out until his turn comes. Then WSE (Seagate, N. Y.) comes in clear and distinct; and Miami, Florida, (WST) is heard, equally loud. WZO a new station at Fort Bliss, is trying out with WUJ at Fort Sam Houston, Texas. WUJ comes back with a roar that is painfully loud.

Then down to 200 meters and just listen to the amateurs! From Denver to New York; from Bismarck, N. D. ("—thirty below hr tonite") to the Fifth District stations down in Texas, Arkansas and Louisiana, all are going strong for it seems to be a good night for radio all over the country. Some are interfering with idle gossip, others are trying to prove to NAJ at Great Lakes, that the amateurs will be a valuable asset in case of war!

During the afternoon I had copied POZ and OUI, the big German stations, sending bank transfers supposedly—war dope most likely—now let's hear what Tuckerton and Sayville have to say in reply. The loading inductances are hooked in and the beautiful fife notes of WGG ring musically through the room. The note varies as the capacity of my body interferes. Colon, Panama, is on and working fast. WSL (Sayville) can be heard fifty feet from the phones. NAO (Charleston, S. C.) is busy with a beautiful note; Darien, Panama (NBA) has a message for the maneuver fleet off Cuba; Arlington, (NAA) is working in code; New Orleans (NAT) is using its arc set on a distant station, and what is this faint voice from afar? NPG (Yerba Buena, Cal.) calling Washington! And here is NPL (San Diego, Cal.) also wanting NAA.....

Is it any wonder the radio enthusiast used to stay awake half the night when old QRN was off the job?

Wilbur Wilkerson, of Kansas City, Kansas, well known to radio amateurs in the middle west by the government call letters 9FF, was killed in battle in France, March 20th. Wilkerson, who was an enthusiastic radio amateur enlisted in the 117th Field Signal Battalion, Co. A., last fall. Secretary Baker, who was at the front at the time Wilkerson was killed, personally attended the funeral. A French officer laid the *croix de guerre* on the coffin as it was lowered into the grave.

A number of inquiries have been received from former experimenters asking why we have not published diagrams of earth-conduction telegraph systems, so that experimenters could communicate without wires, but not by Hertzian waves. The reasons are: First, we do not know what attitude the Government officials would take towards such methods of communication, and second, we do not wish to encourage anything among experimenters which would tend to attract suspicion to their operations. Earth conduction systems are limited in their range, but it may be possible by the use of sensitive vacuum valve amplifiers to increase the distance greatly. Nevertheless, we would advise experimenters not to engage in any form of wireless communication during the war. Time will be better spent in educating themselves in the fundamentals of the art, thus preparing themselves to build better equipment when they are again allowed to open their stations.

It is again necessary to state that we have no definite information concerning the vacuum valve situation. Just where amateurs will be able to purchase evacuated tubes after the war we cannot say; but it is highly probable that such tubes will be available for amateurs' use. It is equally possible that the vacuum tube will came in for considerable use on the part of amateurs as for purposes of transmission. At least the tube will permit communication over short ranges and it will provide a transmitter of greater simplicity than the amateur ordinarily is accustomed to use.

A number of amateurs who are studying the vacuum valve circuits apparently are disturbed at the complicated circuits which they encounter in regenerative systems. It may be said that the majority of systems described by experimenters from time to time work along the same general lines, the difference lying merely in the arrangement of the apparatus or in its connection. There are two ways of obtaining regenerative coupling — by electromagnetic or by electrostatic induction. So long as the plate and grid circuits of the tube are coupled one way or the other, regeneration results.

Have you heard the story about O. A. B? He was an Indiana ham amateur whom the gods of war had placed on a trans-Atlantic cargo vessel. As he neared the submarine zone he became more and more concerned over the possibilities of an attack. Prepared for most anything, he cautiously tuned the apparatus to take in any signals that might be coming in his direction, such as warnings from land stations or vessels within range. His anxiety was increased by constant prodding from his companions. He obtained response, but in an unexpected way. A three-inch shell passed right through the cabin forward of that given over to the radio set, smashing his ports and breaking off the lead-in wires for the aerial.

Leaping from his cabin, he rushed back and forth on the deck and yelled:

"We've been shelled! We've been shelled!"

"Get back in your blooming bunk," the Captain yelled, "and call for help!"

Shivering in the knees, he stammered: "Captain, whom should I call?"

"Call? You confounded lunkhead! Call Paris, New York, Berlin, the Kaiser! Call anybody, anything! Tell them that we are shelled."

Apparently, he followed out instructions to the detail, for, according to the second operator, this is the message he sent out: "To all ships: We've been shelled by something—we don't know what."

There was no doubt later concerning the origin of the shelling, for within fifteen minutes they had a three-hour engagement with a submarine. There were no casualties.

The remarks of A. R. Q., in the British Channel, were almost equally ludicrous. He was requested by a British Patrol vessel to "reduce his wave length and power."

He replied, "Sorry, O. M., our captain won't allow us to take down the aerial."

"Have you heard a wireless signal of late, and what did it sound like?" an inquirer asked in the Association office the other day.

"Yes," was the reply, "we have heard many signals, but they were artificially made."

"I should like very much to hear the old dot and dash buzz of a wireless telegraph set," followed this observation.

"Easy," we told him. "There's a space in the first line of trenches in France waiting for you. Not only can you hear the sputter of wireless sparks there, but plenty of staccato, mezzo, and basso accompaniments."

The inquirer enlisted the same afternoon.

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

D. R. Q., St. Louis, Mo.:

Radio frequency sparks are those occurring at rates above 20,000 per second. This is, of course, above audibility, and no sound will be obtained in the receiving telephone at the receiving station. The radiations from such systems assume the nature of undamped waves, but are not strictly so. In transmitters giving radio frequent spark discharges, it is necessary to interrupt these discharges at the receiving station at an audio frequency approximately 500 or 600 times per second, or possibly more, in order that the maximum response from the telephone can be obtained. Such systems are not widely used. A multiplate or quenched spark discharger is now preferred, in damped wave telegraphy.

Replying to your last query, no wireless apparatus for the present can be purchased by an experimenter or sold by a supply house without permission from the Government authorities. It is considered a violation of the President's order for an amateur to construct radio apparatus during this period. Whether or not the Government will allow you to construct the apparatus you mention in your communication can be ascertained by addressing the District Communication Superintendent of the U. S. Naval Radio Service at Chicago, Ill.

The sounds you hear from the rod of soft iron when it is magnetized by a strong electric current arise from the sudden motion of the molecules of the iron due to magnetization and demagnetization.

* * *

O. E. C., Boston, Mass., inquires:

Ques.—(1) I would like the details of construction of an audio frequency transformer for amplifying the signals from a silicon detector by means of a three-electrode vacuum valve. I have tried the various designs shown from time to time in publications, but have been unable to obtain results. Please state the dimensions of a reliable, working transformer.

Ans.—(1) You can obtain considerable amplification of the incoming signals by merely connecting the grid and filament of a vacuum valve across the usual fixed condenser in the crystal rectifier circuit. This condenser should be of small capacity and care should be taken that the grid element of the vacuum valve is connected on the high potential side of the secondary coil. Either an inductively or conductively coupled transformer may be employed. They should be connected in shunt to the condenser. One type of coil which has given good results has primary inductance of 20 henries and secondary inductance of 90 to 100 henries (fitted with an iron core). The primary and secondary coils are generally wound with No. 32 and No. 34 B. & S. wire, respectively. With certain types of vacuum valves, it is desirable in a circuit of this kind to insert a grid battery in series with the grid, that is to say, a four-volt battery unit is shunted by a potentiometer and connected between the negative side of the filament and the terminal of the secondary winding of the iron core transformer opposite to that connected to the grid.

That you were unable to obtain the desired results with the transformer you describe in your communication is likely due to an imperfect vacuum tube. It may have nothing to do with the design of the transformer. Perhaps the construction of this tube was such that it did not give the desired operating characteristic for audio frequency amplification. But this can be compensated for to a certain extent by using the grid battery mentioned.

* * *

S. W. H., Glencoe, Ill., inquires:

Ques.—(1) Is there any difference between a secondary shunt condenser of .001 microfarad capacity, a plate circuit condenser of .001 microfarad capacity, and a telephone condenser of the same value?

Ans.—(1) There is no difference, but the telephone condenser is usually of fixed capacity.

Ques.—(2) Is a variable static shunt and a potentiometer for the high voltage battery necessary for an undamped receiving set?

Ans.—(2) The potentiometer is not absolutely necessary, but it gives a closeness of control of the plate circuit voltage that cannot be obtained otherwise. A shunt across the grid condenser of a vacuum tube which is highly exhausted is essential, for otherwise, the charge accumulating on the grid will reach such a high negative value as to open up the plate circuit and render the tube inoperative.

Ques.—(3) Please explain how to make a variable static shunt.

Ans.—(3) It may be constructed by mounting two binding posts with a strip of paper between them. Several lead pencil lines may be drawn from one post to the other until the desired resistance is obtained.

Ques.—(4) Can you tell me where I can purchase tubes 40 inches in length and six inches in diameter for use as tuning coils?

Ans.—(4) These can be purchased from Ware & Co., Watt street, New York.

Ques.—(5) Referring to the diagram on page 335 of the January, 1918, issue of THE WIRELESS AGE, I do not understand the function of the coils L-8, L-9, and the changeover switch S-1.

Ans.—(5) Coils L-8, L-9, constitute a regenerative coupler; that is, the plate and grid circuits are magnetically coupled at that point. Please take note in this diagram, that the coils L-6, L-8, should be connected and that the potentiometer, Po, should be shunted around the plate battery B. The changeover switch S-1 changes the connections of the apparatus so that either short wave transformer L-1, L-2, or long wave transformer L-5, L-6 can be connected to the vacuum tube. During the war period you are not permitted to construct wireless apparatus of any kind.

* * *

R. W., Plainfield, N. J., inquires:

Ques.—(1) What should be the primary voltage of a coil to deliver a 6-inch spark?

Ans.—(1) 12 to 24 volts D.C. should be employed.

Ques.—(2) What is the watt rating of the coil?

Ans.—(2) It would consume approximately 125 watts.

Ques.—(3) What size should the core be?

Ans.—(3) It should be 1½ inches in diameter and 14 inches in length, composed of a bundle of No. 28 soft iron wires.

Ques.—(4) What should be the dimensions of the secondary pies or windings?

Ans.—(4) The secondary should be divided up into 20 sections. The entire winding will require approximately 12 lbs., which should be equally divided between the sections. When completed it will be about 10 inches in length. Use No. 32 B. & S. wire.

Ques.—(5) Would No. 14 S. C. C. wire be correct for the primary winding?

Ans.—(5) Use No. 12 B. & S. S.S.C. for wire wound in two layers.

Comments on Receiving Phenomena

READERS of the February issue of THE WIRELESS AGE noticed on page 440, comments of the radio operator of the U. S. S. Roosevelt on certain phenomena of receiving which he observed in the North Pacific and Bering Sea, namely, that a decided change of weather, such as from stormy to calm and vice versa, invariably is accompanied by good receiving weather, i. e., no static or atmospherics. This operator's remarks have been both substantiated and disproven by observers at several points.

B. M. Joachim of St. Raymond, Quebec, Canada, comments as follows:

"P. B. D., Radio Operator, U. S. S. Roosevelt, in the last issue of THE WIRELESS AGE inquired whether any wireless operator had noticed the phenomenon that receiving is better when a sudden change in weather is to be expected. I must say that I have very often noticed the fact. Assuming 50 per cent. to be a fairly good average reception of Washington Time Signals, this percentage was doubled when changes in the weather conditions were to take place.

"My opinion is that the aerial is a pretty good barometer for the attentive operator.

"In case of Aurora Borealis (they are very important here), good reception is quite impossible, for reasons which I cannot explain.

"My station is located 71° 50′ west of Greenwich by 47° 55′ north; in a cold, mountainous country. This winter's lowest temperature was 62° F. below zero on December 30, 1917."

V. C. McIllvaine, radio operator on the S. S. Freeport Sulphur No. 2, apparently has obtained exact opposite results. He says:

"Referring to comment of P. B. D., radio operator, U. S. S. Roosevelt, page 440 of February issue of THE WIRELESS AGE, I wish to state that my observations seem to be exactly opposite to his. While not working in the North Pacific or Bering Sea, but rather in the Gulf of Mexico, during the winter months especially, a blow from the North is invariably preceded by static. The static would precede the 'norther' by from 6 to 18 or 20 hours, and the strength of the blow may be roughly estimated by the intensity of the static. During the blow, however, the atmosphere is very clear, being very excellent weather for radio work."

An amateur of Ohio has observed results similar to P. B. D. He writes as follows:

"I notice that P. B. D., radio operator, U. S. S. Roosevelt, states that he has noticed that a decided change in the weather during the winter is invariably accompanied by good receiving weather. I operated a wireless station in western Ohio for several years and have often remarked the same thing, which, for us, was especially noticeable at a time when the weather was just commencing to moderate considerably after a cold wave. At such times not only was there a remarkable freedom from static, but the signals came in with unusual loudness and there was less than the usual amount of 'fading' with distant stations. The best receiving results that we ever obtained were at these intervals.

"I should like to hear the experience of others."

A Radio Phenomenon

SMOKE passing through an aerial has the power to transmit heavy deposits of static. Perhaps ship operators have been aware of this fact for a long time, but it is probably news to many land amateurs. The phenomenon was first called to my attention at Fort Leavenworth where the college station "WUV" experienced considerable trouble from a mysterious source. Major J. O. Mauborgne, who took charge of the Signal School there last fall, quickly traced the trouble to its source and proved conclusively that the frequent violent surges of static which would appear and suddenly disappear on nights which were unusually free from atmospheric disturbances, were caused by smoke clouds from passing trains. He expressed a determination at the time to write a paper on his investigations of the phenomenon, but was called for service in the radio laboratories in Washington and has no doubt been too busy to give the matter further thought.

The writer, whose aerial was also exposed to smoke clouds from passing trains, made frequent tests up until the time the stations were ordered closed, and a passing train never failed to disturb the station when the wind was favorable for passing the smoke through the aerial. The charge of static would "spill" the audion and made a fine display in the variable condenser which was used in series with the antenna to shorten the wave-length. F. W. J.

Improved Apparatus

Bunnell Straight Line Radio Key (Ghegan Patent)

The object of this design (figure 1) is to provide a radio key having re-

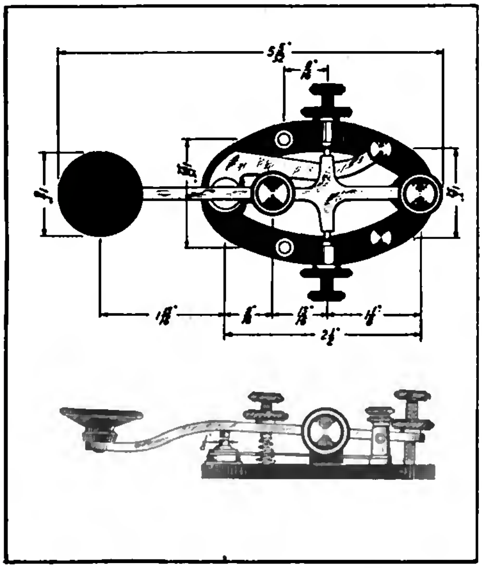


Figure 1—Bunnell straight line radio key

movable or renewable contacts that can be kept in perfect alignment until completely worn out. This not only economizes in respect to renewals but by giving better surface contacts between the points, eliminates the fading or changing of strength of signals caused by imperfect or unevenly worn points. This is accomplished by mounting the lower contact point on a ball-bearing stud having a clamping device for holding it permanently when in proper adjustment with the upper contact.

The upper contact is not mounted directly on the lever, but is attached to the end of a set screw passing through the lever directly over the lower contact.

By this arrangement increased lever-play, caused by wearing of contacts is not taken up at the back adjustment screw as in the ordinary key, but by lowering the upper contact which permits uniform surface contact until the points are worn off. This is not possible with the usual type of key.

This arrangement has the further advantage of keeping the lever knob always at the same height from the operating table. Operators will find this a very desirable key.

A New Small Squirrel-Cage Induction Motor

A new line of induction motors has been recently placed on the market by the Crocker-Wheeler Company, Ampere, N. J. These motors, known as the C.W. Form P Motors, are of the squirrel-cage type, ranging in size from one-half to three horsepower, and are designed for constant-speed operation on sixty-cycle polyphase circuits.

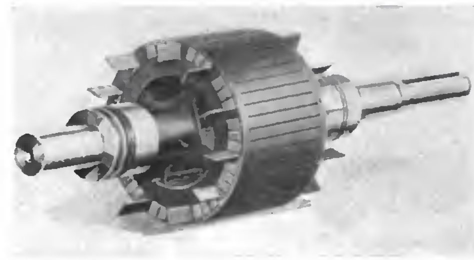


Figure 2—Stator having well insulated windings

The mechanical construction is compact, rugged, and simple. Rigid frames and end shields, liberally designed shafts and bearings, ample air gaps and good insulation enable these motors to withstand the severe service to which these machines are generally put. They possess good starting torque and high power-factor.

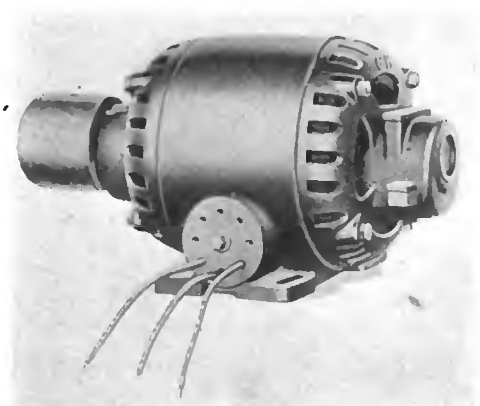


Figure 1—The squirrel cage motor assembled

Among the special features of these motors is their efficient ventilation. A number of the rotor bars project for a short distance at each end of the rotor core. These projecting ends serve as efficient fans. Attached to the inside of each of the bearing shields is a pressed steel guide that separates the incoming from the outgoing air. Air is thus drawn into the motor at each end through openings near the shaft

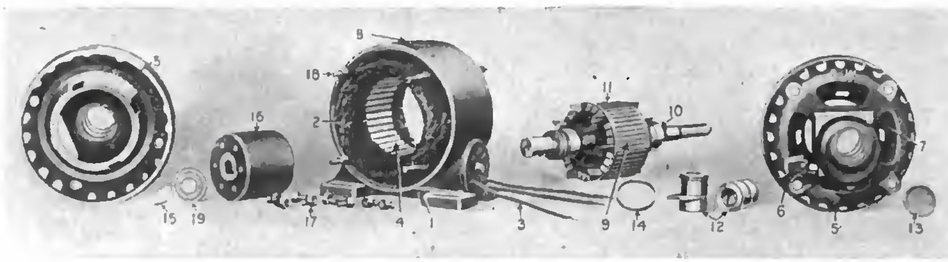


Figure 3—The motor disassembled

and then forced by the fans against the stator windings, around the ends, and finally out through the holes near the outer periphery of the shields. This construction prevents the outgoing warm air from mixing with the air being drawn into the motor. A maximum cooling effect with a minimum of windage loss is thus obtained.

Strong insulation of the stator windings is obtained by placing the coils in well insulated slots and impregnating the complete core and winding with a special varnish which renders them moisture-proof and enables them to withstand acid fumes. After the core and coils are removed from the impregnating tanks they are baked, and again dipped in varnish and baked.

The bearings are large, with oil grooves so located that no matter in what direction the belt-pull may be there will be a film of oil between the shaft and the bearing, thus reducing friction to a minimum. Dust and dirt are kept out of the bearings by sheet-metal caps at the ends and by self-closing oil-well covers.

Slotted feet cast integral with the stator frame facilitate accurate belt-tension adjustment. The assembled product is shown in figure 1, the stator in figure 2, and the complete disassembly in figure 3.